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REPORT OF OPTICAL GROUND TRUTH MEASUREMENTS FOR 5 AUGUST, 1973, TEST SITE NUMBER 548532, IN SUPPORT OF THE SKYLAB MULTISPECTRAL SCANNER

by

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16. Abstract

As part of EREP investigation S410 (Contract NAS9-13272), aimed at assessing the atmospheric effects on data collected by the Skylab multispectral scanner (S192), ground measurements of atmospheric properties were made at a test site (EREP TEST/SITE 548532) in Ingham County, Michigan, in support of ERIM aircraft over-flights and a Skylab track 61 overpass on 5 August 1973. The ground measurements will be utilized as a data base for quantifying atmospheric properties and terrain object discriminability at the ground, while aircraft and Skylab data will enable computing object discriminability for extended atmospheric paths.

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ABSTRACT

As part of EREP investigation S410 (Contract NAS9-13272), aimed at assessing the atmospheric effects on data collected by the Skylab multispectral scanner (S192), ground measurements of atmospheric properties were made at a test site (EREP TEST/SITE 548532) in Ingham County, Michigan, in support of ERIM aircraft overflights and a Skylab track 61 overpass on 5 August 1973. The ground measurements will be utilized as a data base for quantifying atmospheric properties and terrain object discriminability at the ground, while aircraft and Skylab data will enable computing object discriminability for extended atmospheric paths.

1.0 INTRODUCTION

As part of EREP investigation S410 (Contract NAS9-13272), aimed at assessing the atmospheric effects on data collected by the Skylab multispectral scanner (S192), ground measurements of atmospheric properties were made at a test site (EREP TEST/SITE 548532) in Ingham County, Michigan, in support of ERIM aircraft overflights and a Skylab track 61 overpass on 5 August 1973. The ground measurements will be utilized as a data base for quantifying atmospheric properties and terrain object discriminability at the ground, while aircraft and Skylab data will enable computing object discriminability for extended atmospheric paths.

The ground measurements were carefully coordinated with the aircraft and Skylab efforts in order that all data be complementary. Personnel from ERIM's Infrared and Optics Division deployed to the site, set up instrumentation, and began data collection two hours prior to the satellite overpass time of 11:00 a.m. EDT. Approximately one hour prior to satellite overpass time, the ERIM C-47 aircraft began the first of 4 successive data collection passes over the test site. Aircraft passes were made at altitudes of 10K, 5K, 2K, and 1K feet with the 2K ft pass being simultaneous with the time of satellite overpass. Data acquired with the aircraft included twelve channels of terrain radiance information collected by the M-7 multispectral scanner and aerial photography for documentation purposes.

Ground measurements included total and diffuse broad band irradiance and spectral irradiance to determine the characteristics of the incident radiation. Radiance measurements of standard reflectance panels were made to provide data that will assist in the analysis of the aircraft data. Additionally, a Bendix RPMI was used to measure both radiance and irradiance in the four ERTS equivalent bandwidths. This data will be used to compare the atmospheric effects manifested in the ERTS spectral channels with effects included in the spectral channels of Skylab. Finally, an upward looking camera with fish eye lens documented the sky conditions at regular intervals.

This report presents the results of the ground measurements of optical radiation parameters as functions of wavelength and time of day, as observed on 5 August 1973. The results are presented in reduced form,

with instrument calibrations incorporated. Also included are laboratory spectral reflectance curves for the standard reflectance panels and a tabulation of meteorological data as reported by local weather reporting stations.

2.0 GROUND MEASUREMENT PROGRAM

In the following material, the site layout is presented and the various instruments and calibration techniques are described. The measurement procedures utilized are also outlined with pertinent comments included.

2.1 SITE

The test site was located on a recently mowed hay field in Ingham County near the community of Williamston, which is roughly 42° 39' north latitude, 84° 14' west longitude. All of the ground measurements were conducted at this site. A set of calibration panels were placed on the site and were available for measurement. The calibration panels are of sufficient size to be "seen" by the scanner in the airplane, and thus provide a "known" target for the scanner. The panels consist of:

1. Five (5) 20 x 40 ft. canvas panels that were utilized as gray-scale reflectance standards.
2. Three (3) 20 x 40 ft. canvas panels which were used as red, green, and blue calibrated color standards.

Figure 1, shows the relative positions of the calibration panels and the ground instrumentation.

Samples were taken from the eight calibration panels after the ground measurements were completed. The samples were subsequently measured in the laboratory to determine the directional reflectance (ρ_d) of the panels.

2.2. INSTRUMENTATION

To facilitate the understanding and use of the ground truth measurements taken, a brief description of the instrumentation used for these measurements is presented. The instrumentation provided direct measurements of spectral and broad band irradiance as well as spectral radiance in the visible and near-infrared portion of the spectrum.

A. Eppley Black and White Pyranometer (Model #8-48)

The Eppley pyranometer measures broad band radiation in the visible near-infrared region. The pyranometer has a hemispherical field of view. The detector in this instrument is a differential thermopile with the hot-junction receivers blackened (with an Eppley-Parson's black coating) and the cold-junction receivers whitened (with Barium Sulfate). The detector is covered with a glass hemisphere which is transparent from .28 to 2.8

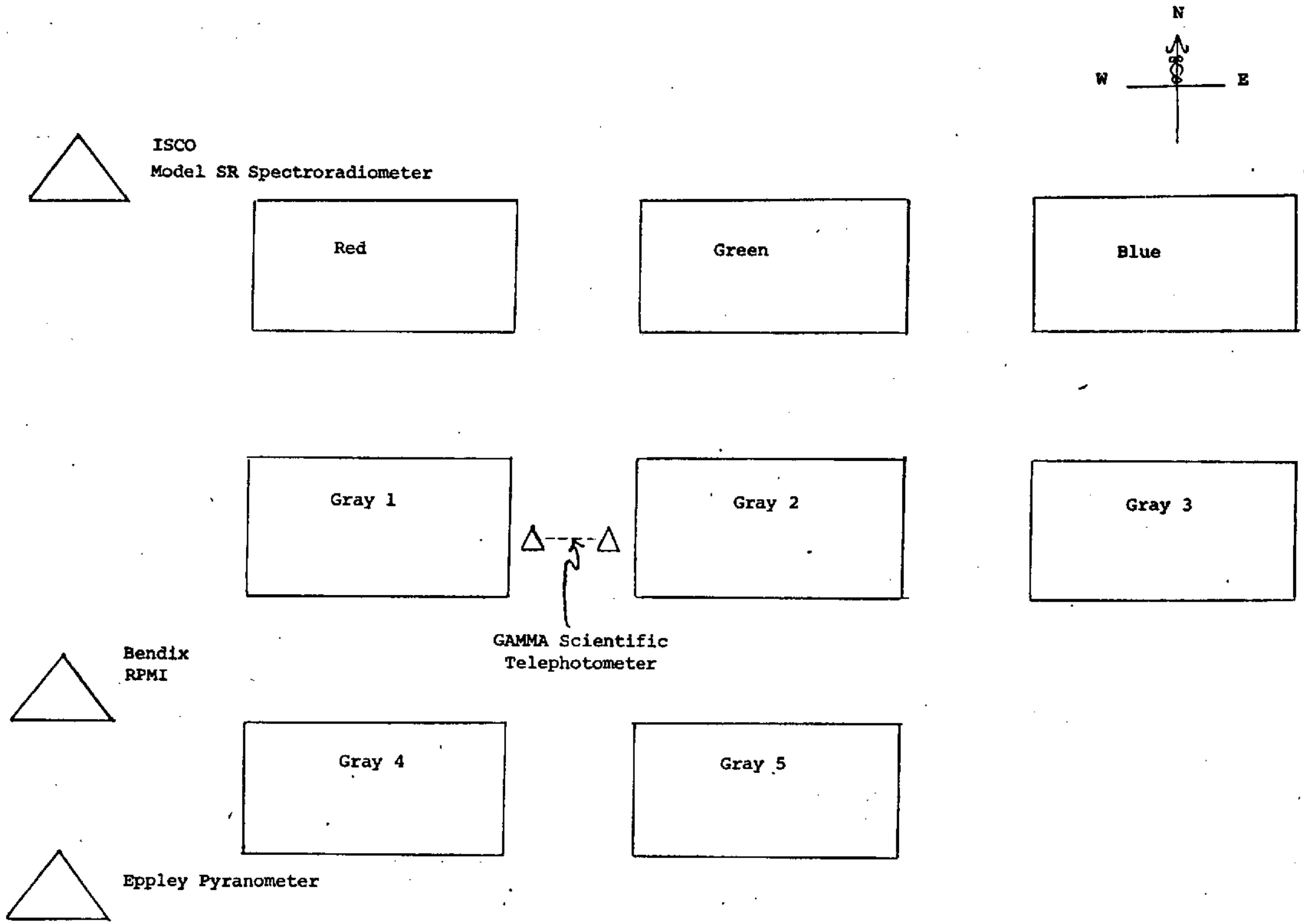


Figure 1

Calibration panels and Test Instrument Field Positions. Area encompassed approximately 200' x 250'.

micrometers. The low level output signals from the thermopile are amplified and recorded on a chart recorder.

The two pyranometers used were calibrated by Eppley Laboratory Inc. The calibration was checked using a standard of spectral irradiance traceable to NBS. An overall accuracy for the pyranometers, amplifiers, and recorder may be derived from the following:

1. The output of the pyranometer changes by less than $\pm$ 1.5% as a function of temperature over the -20 to +40°C temperature range.
2. There is less than a $\pm$ 1% deviation in linearity from the expected linear relationship between the magnitude of the incident irradiance and the pyranometers output signal.
3. The pyranometer's angular response deviates by less than $\pm$ 2% from the expected angular cosine response.
4. The gain of the amplifiers used was determined to an accuracy of $\pm$ 1%.
5. The chart recorder has an accuracy of $\pm$ 1%.

Assuming that the errors outlined above are Gaussian in nature and independent of each other, the overall accuracy of the system may be calculated by taking the square root of the sum of the squares of the errors. Thus, the accuracy of the pyranometer measurements is calculated to be approximately $\pm$ 3%.

B. <u>ISCO SR Spectroradiometer</u>

This instrument is used to measure the solar spectral irradiance in the wavelength region 0.4 through 1.35 micrometers. A transmissive diffusing plate is used to achieve a hemispherical field of view. The light from the diffuser is chopped and passed through an interference filter before it reaches the silicon detector. The signal from the detector is amplified and then synchronously detected. The output of the synchronous detector is then recorded on a strip chart recorder. The spectral bandpass of this instrument is determined by the interference filter. The bandwidth of the interference filter is 15 millimicrons in the 0.35 to 0.75 micrometer region and 30 millimicrons in the 0.75 to 1.3 micrometer region.

The ISCO SR Spectroradiometer was calibrated against two sources of spectral irradiance, both of which are traceable to NBS. The accuracy of the sources is ± 4% in the spectral region in which the ISCO operates. The instrument was found to have a repeatability of better than ± 5%. Assuming that the errors outlined above are Gaussian in nature, the overall accuracy of the ISCO Spectroradiometer may be calculated by taking the square root of the sum of the squares of the errors. Thus, the accuracy of the ISCO Spectroradiometer is approximately ± 6.5%. This accuracy is valid only when the source being measured does not extend beyond an angle of 50° where the angle is measured from the surface normal of the diffusing plate. For angles greater than 50°, the response of the instrument differs significantly from the expected cosine response. The angular response degradation increases as the angle increases beyond 50°.

C. GAMMA Scientific Telephotometer (Model 2000)

The Model 2000 is a photometer which is used to measure the magnitude of reflected radiation off a surface in selected spectral regions. Spectral bands of approximately 200 Å are obtained using interference filters at nominal center wavelengths of 0.433, 0.500, 0.533, 0.566, 0.600, 0.633, 0.666 and 0.700 micrometers. Five field of views of 2', 6', 20', 1° and 3° are available; the 3° field of view was used for all of the reported measurements.

The GAMMA telephotometer was calibrated with a radiance source that consisted of a fiber board painted with 3M White Velvet paint illuminated by a standard of spectral irradiance.

The accuracy of the GAMMA telephotometer may be calculated from the following:

1. The accuracy of the spectral irradiance standard is ± 4%.
2. The bidirectional reflectance (ρ') of the 3M White Paint was determined to an accuracy of ± 5%.
3. The instrument had a ± 5% repeatability.

Again assuming a Gaussian distribution, the overall accuracy is calculated to be approximately ± 8%.

D. Bendix RPMI

The Bendix RPMI was used to measure both radiance and irradiance. The RPMI has four spectral filters which correspond to the ERTS MSS bands 4, 5, 6 and 7 (Earth Resources Technology Satellite-MultiSpectral Scanner). Appendix 1 has been devoted to the details of calibration and interpretation of the RPMI data.

2.3 MEASUREMENT PLAN

The measurement plan was designed to produce a series of measurements of the incident broad band and spectral irradiance and the radiance of the canvas panels, (1 and 2) with time as a parameter.

The two Eppley pyranometers measured the incident broad band irradiance. Both of the pyranometers were positioned so that their active surfaces were horizontal and thus viewed the entire sky. One of the pyranometers viewed both the sun and the sky while the other was shaded from the sun and thus could view only the sky.

The ISCO measured the incident spectral irradiance in the .4 to 1.35 micrometer spectrum. The diffusing plate of the ISCO was positioned horizontally so that it could also view the sun and sky. Two types of measurements were made with the ISCO. In the first type, both the sun and the sky were measured together (referred to as a measurement of "total" irradiance). In the second type of measurement, the sun was shaded, and only the sky was measured (referred to as a measurement of "diffuse" irradiance).

The GAMMA Scientific telephotometer measured the spectral radiance of the gray reflecting panels numbers 1 and 2. The center wavelengths of the spectral radiance measurements were .433, .500, .533, .566, .600, .633, .666, and .700μm. The panels were viewed with a depression angle of 68° measured from the horizon. Gray panel number 1 was measured with the GAMMA pointing in a westerly direction (azimuth of 270°) while gray panel number 2 was measured with the GAMMA pointing in an easterly direction, (azimuth of 90°).

The Bendix RPMI measured:

1. "total" incident irradiance in the 4 RPMI spectral bands.
2. "diffuse" incident irradiance in the 4 RPMI spectral bands.

3. "direct" solar irradiance in the 4 RPMI spectral bands. (Note: To measure the "direct solar irradiance, the diffusing plate's normal is pointed at the sun and most of the sky is excluded by installing the tube to restrict the field of view.)

As time permitted, measurements of sky radiance with a zenith angle of 0° were also made.

Documentation of the changing cloud patterns were obtained by taking sky pictures at regular intervals. The pictures were taken with a camera equipped with spectral filters which enhance cloud sky contrast and a fish eye lens which enables the entire sky to be photographed.

The ground measurements for all instruments were cycled at 15 minute intervals commencing before the first overpass and continuing until the aircraft had completed data collection over the test site.

3.0 DATA PRESENTATION - DISCUSSION OF RESULTS

A discussion of the results precede a presentation of the measurement data in the following text. The measurement data presented consists of 1) broad band irradiance, 2) band irradiance, 3) spectral radiance, and 4) spectral irradiance.

The measurement data is followed by a tabulation of the hourly weather reports for southern lower Michigan, and the laboratory measurements of directional reflectance on the calibration panels. The sky pictures are not presented since the sky did not have any definable clouds, only a uniform haze which does not show up on the photographs.

3.1 BROAD BAND IRRADIANCE (Eppley Pyranometer)

The curve in Figure 2 shows an increase in total broad band irradiance from 9:00am to 11:00am (all times are EDT). The increase is expected and is accounted for by the sun's changing zenith angle. The diffuse broad band irradiance decreases slightly from 9:00am to 11:00am. After 11:00am, the total broad band irradiance levels off while the diffuse broad band irradiance increases. The sudden changes in the two broad band irradiance components is a result of the unusual on site weather conditions. Very early on the morning of August 5, there were clouds in the vicinity of the site which "burned" off before the data acquisition routine commenced.

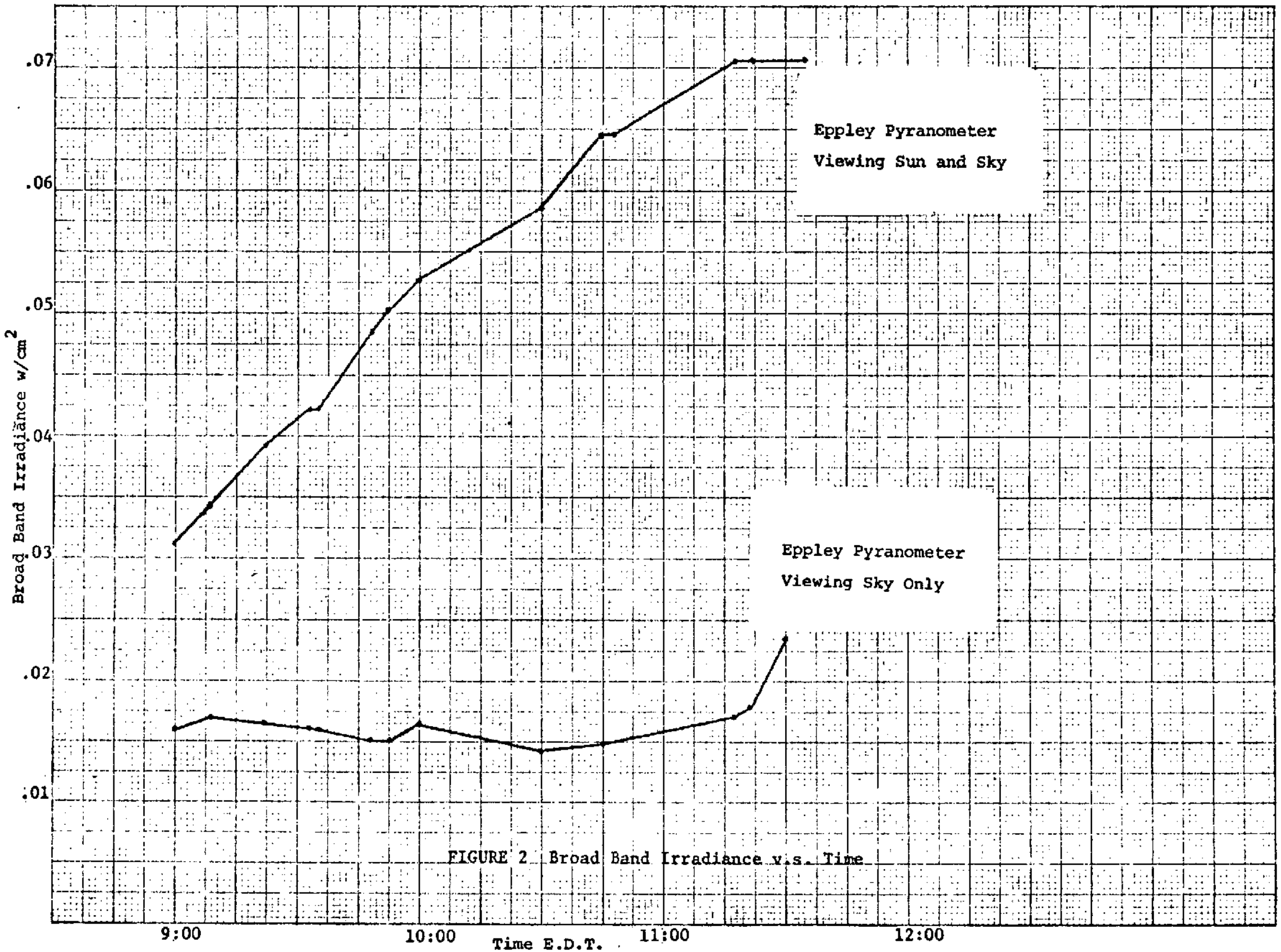


FIGURE 2 Broad Band Irradiance v.s. Time

After the clouds burned off, a haze condition existed. This haze decreased from 9:00am to around 11:00am at which time the amount of haze started to increase. The haze gradually increased until about 11:35am (the data does not cover this time) when clouds began to appear. The leveling off of the total broad band irradiance and the increase in the diffuse broad band irradiance after 11:00am is caused by the meteorological conditions.

3.2 IRRADIANCE (Bendix RPMI)

All of the Bendix RPMI data were reduced using proportionality constants derived for the standard lamp (see the Appendix). This was done so that the user could correct the data for a source whose spectral distribution is markedly different from the spectral distribution of a tungsten lamp.

The data from the Bendix RPMI (figs. 3-6 and table 1) also show the effects of the haze. The direct component of irradiance decreases after 11:15am as a result of the increased haze. The decrease in direct and total irradiance observed at approximately 10:20am is due to an instrument zero shift. The dashed line represents the "expected" values for that time. Excepting the anomalous points mentioned above, the direct and total irradiance increase from 9:00am to 11:00am while the diffuse irradiance decreases slightly.

The difference between direct and total irradiance increases with longer wavelengths. This results from decreased scattering of light by very small particles as the wavelength of light increases. The fact that the direct irradiance in some bands is higher than the total irradiance is expected. For the direct irradiance measurements, the receiver is positioned so that its surface normal is directed at the sun. For the total and diffuse measurements, the receiver normal is positioned parallel to the earth's gravitational vector.

Thus, the direct solar radiation intercepting the receiver will be dependent on the receiver pointing. It can be expected that the direct measurements values (E_{DIR}) will exceed the total measurement values (E_T). The differences will be approximated by the relationship

$$E_T - E_{DIFF} = E_{DIR} \cos \theta$$

where θ is the zenith angle of the sun and E_{DIFF} is the diffuse component of irradiance.

3.3 SPECTRAL RADIANCE (Gamma Scientific Telephotometer)

The data from the Gamma Scientific Telephotometer (figs. 7-12) show an increase in panel radiance as a result of the increasing irradiance incident upon the panels. Careful examination of the spectral radiance data show that the ratio of the radiance values of the two gray panels change with time. The change is caused by the varying position of the sun relative to the panels whose reflectance is not diffuse. Note that gray panel #1 was measured with the Gamma pointing west while the Gamma pointed east for the measurements on panel #2. Previous bidirectional reflectance measurements on similar canvas panels has indicated that the changes observed are due to bidirectional reflectance effects. Laboratory bidirectional reflectance measurements were not made on these panels as funding was not available. The data taken at 9:00am and 10:00am have not been included in this report because of anomalies traceable to mistakes in data collection.

3.4 SPECTRAL IRRADIANCE (ISCO Spectroradiometer)

The spectral irradiance data is presented in both a graphical (figures 13-54) and a tabular format (tables 2-23). The graphical data is self-explanatory; however, the tabular data requires some clarification. For the tabulated data, the column labeled cumulative integrated irradiance gives the integrated value of spectral irradiance from the first wavelength, (λ = .4μm) to any of the subsequent wavelengths in the table. Therefore, to determine the irradiance in a band (e.g. λ_1 to λ_2), all that is necessary is to subtract the cumulative integrated value at λ_1 from the value at λ_2. The final value in the table is the broad band irradiance in the .4 to 1.35μm spectrum.

It is also noted that the wavelength .75μm is repeated, and two different values for the spectral irradiance at .75μm are given. This occurs at the wavelength at which the ISCO changes spectral ranges and hence spectral resolution. There is a water absorption band in the vicinity of .75μm which may cause the apparent discontinuity in the data. The first ISCO data value at .75μm is used in the integration, and plotted in the curves, since

the spectral resolution of the first value is better than for the second value.

The spectral irradiance data acquired by the ISCO spectroradiometer are in general agreement with the pyranometer and RPMI data. The total spectral irradiance increases from 9:00am to 11:15 am and the diffuse spectral irradiance stays approximately constant until around 11:30am. At 11:30am, the total spectral irradiance values level off as a function of time and the diffuse irradiance values increase as a result of the haze build-up. The spectral dips at .93 and 1.12 micrometers are the result of water absorption bands at those wavelengths. The diffuse spectral irradiance data taken at 10:48am are not presented because of anomalies traceable to mistakes in data collection.

3.5 WEATHER DATA

The weather data is taken from hourly weather reports from ten weather stations in southern lower Michigan. The reports are tabulated according to the city nearest the station. The cities are: Lansing, Jackson, Battle Creek, Grand Rapids, Bay City, Flint, Detroit City Airport, Detroit Metro Airport, Ypsilanti, and Pontiac. These stations effectively circle the test site and thus provide regional weather information. Interpolations between stations and over the test area can be obtained using the multiple inputs.

One should note that the hourly weather reports for the Lansing area indicate a clear sky. This observation is in direct contradiction with our weather observations presented earlier. The explanation for the discrepancy lies in the fact that our definition of a clear sky is more stringent than the one used by the weather service. The tabulated weather reports (table 24) are preceded by a map (figure 35) of southern lower Michigan.

3.6 DIRECTIONAL REFLECTANCE (Beckman DK-II)

The laboratory measurements of directional reflectance (ρ_d) on the canvas calibration panels were made using a Beckman DK-II reflectometer.

The panels were measured using Barium Sulfate ($BaSO_4$) as a reference standard. The data presented (figures 36-43) has been corrected for the reflectance of Barium Sulfate and can be used as absolute data. The directional reflectance measurements were checked on a Cary-14 reflectometer. While the measurements produced by the two instruments agree qualitatively, the data do not agree quantitatively. The source of the quantitative discrepancy has at this time not been determined, and it is impossible to say which instrument is giving the better results. Because of the discrepancy, the data should be used with the greatest caution when making quantitative comparisons. At the lower reflectances (i.e. Gray 1) the discrepancy observed indicates the measurements could be in error by a factor of 2 or more. For the higher reflectors (i.e. Gray 5), the observed discrepancies amount to only around 6%. Therefore, quantitative conclusions based on the low reflectances should be avoided if at all possible.

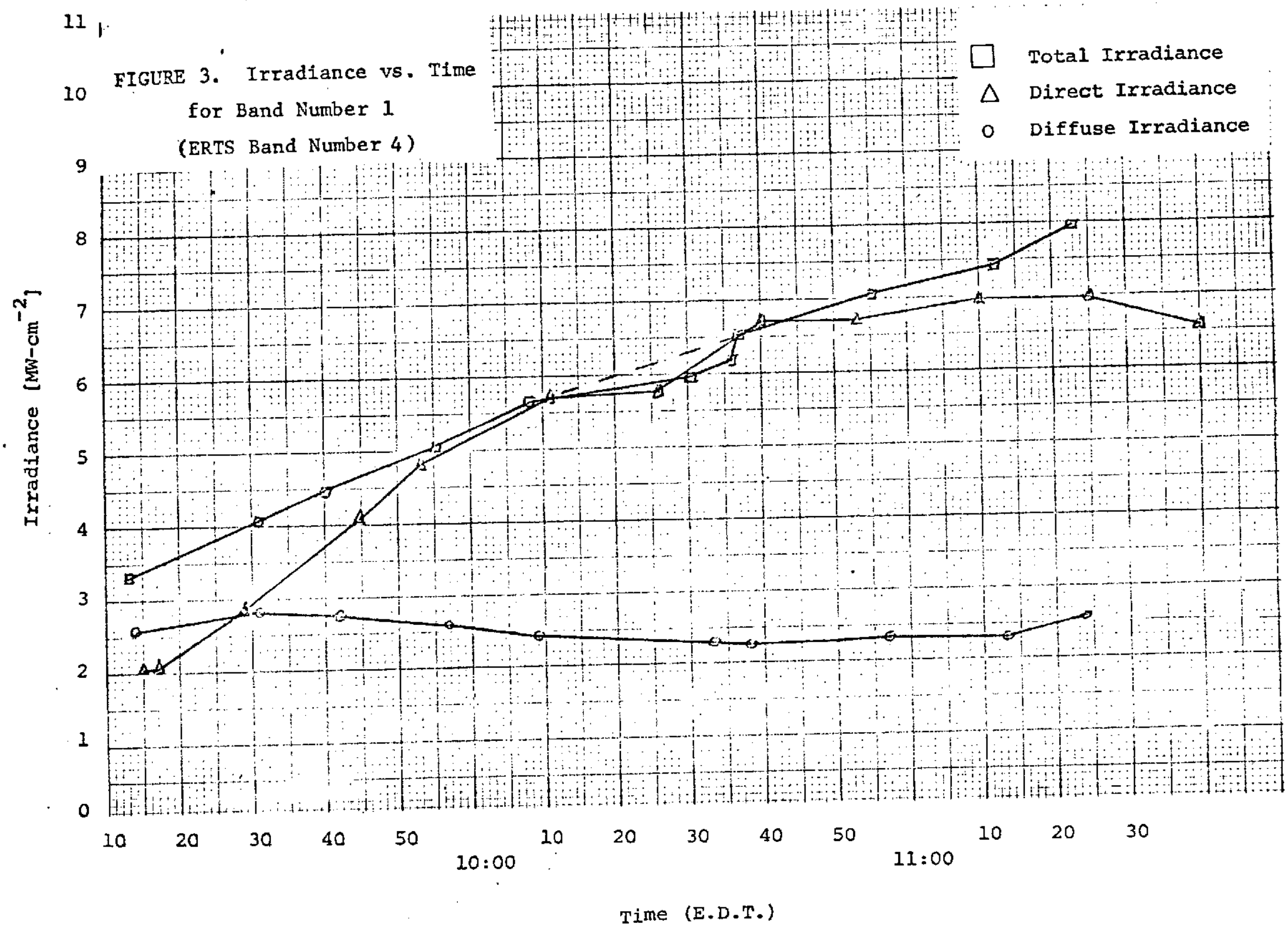


FIGURE 3. Irradiance vs. Time
for Band Number 1
(ERTS Band Number 4)
Total Irradiance
Direct Irradiance
Diffuse Irradiance
Irradiance [MW-cm^{-2}]
0
1
2
3
4
5
6
7
8
9
10
11
10 20 30 40 50 10 20 30 40 50 10 20 30
10:00
11:00
Time (E.D.T.)

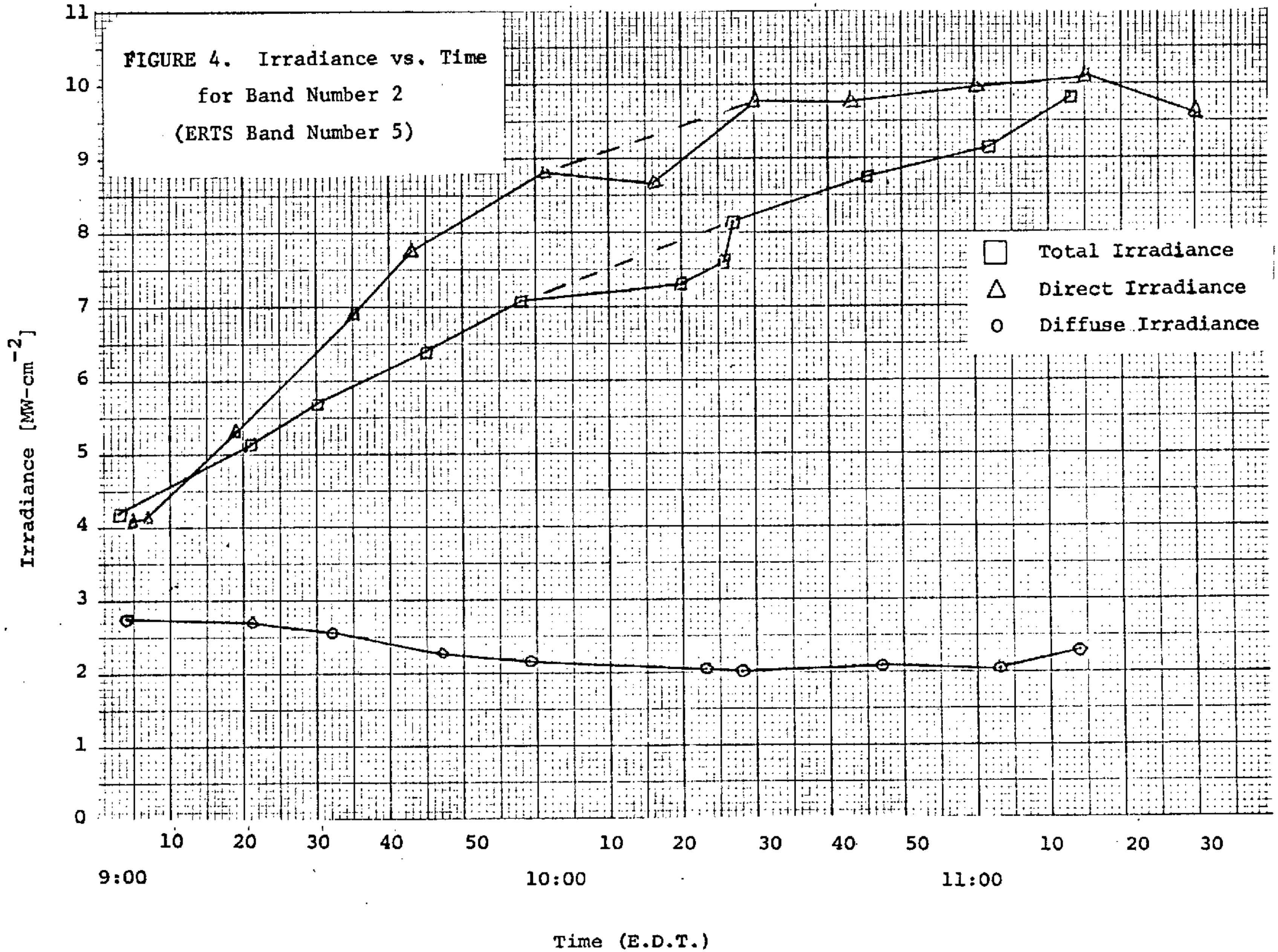
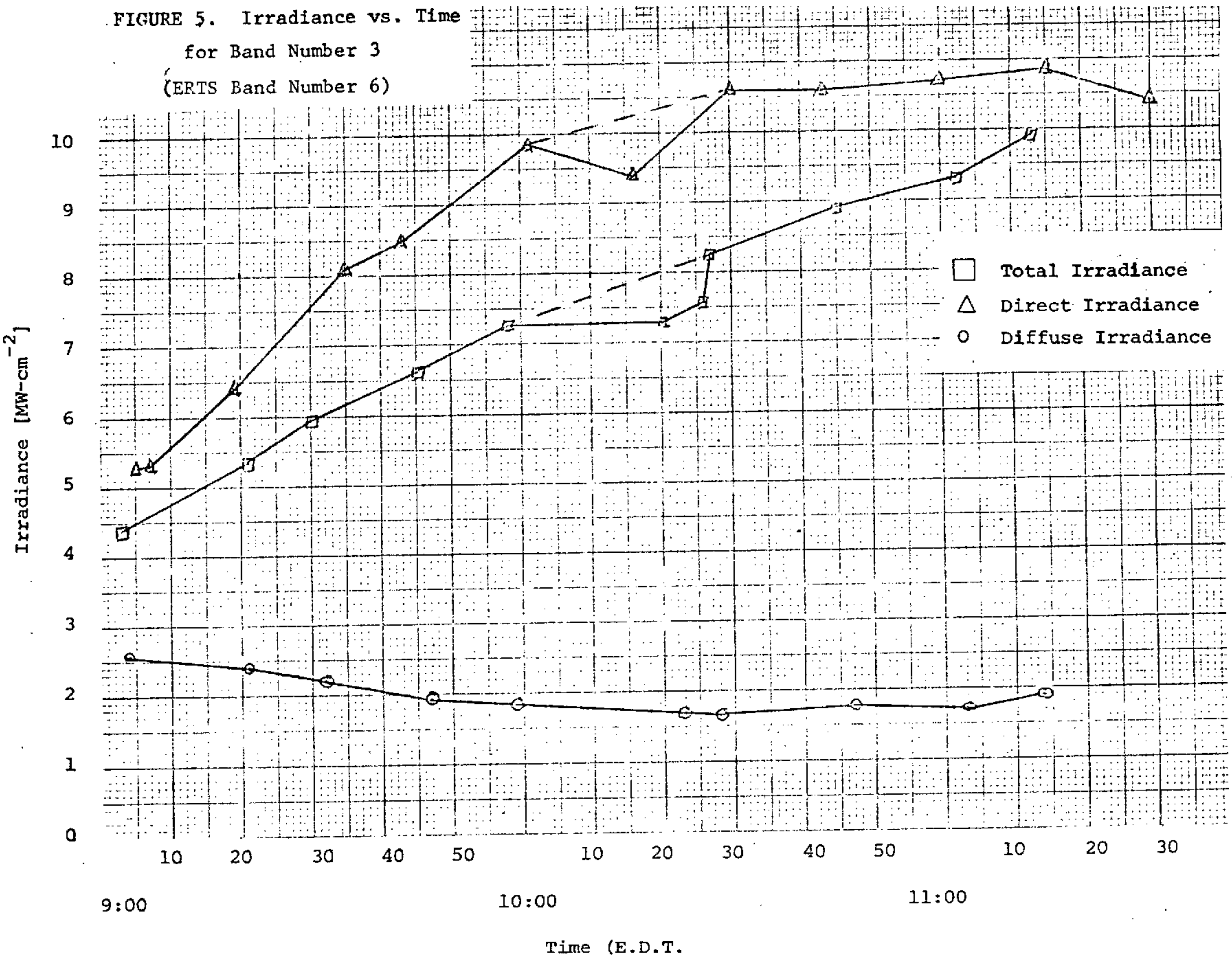


FIGURE 4. Irradiance vs. Time for Band Number 2 (ERTS Band Number 5)

FIGURE 5. Irradiance vs. Time for Band Number 3 (ERTS Band Number 6)



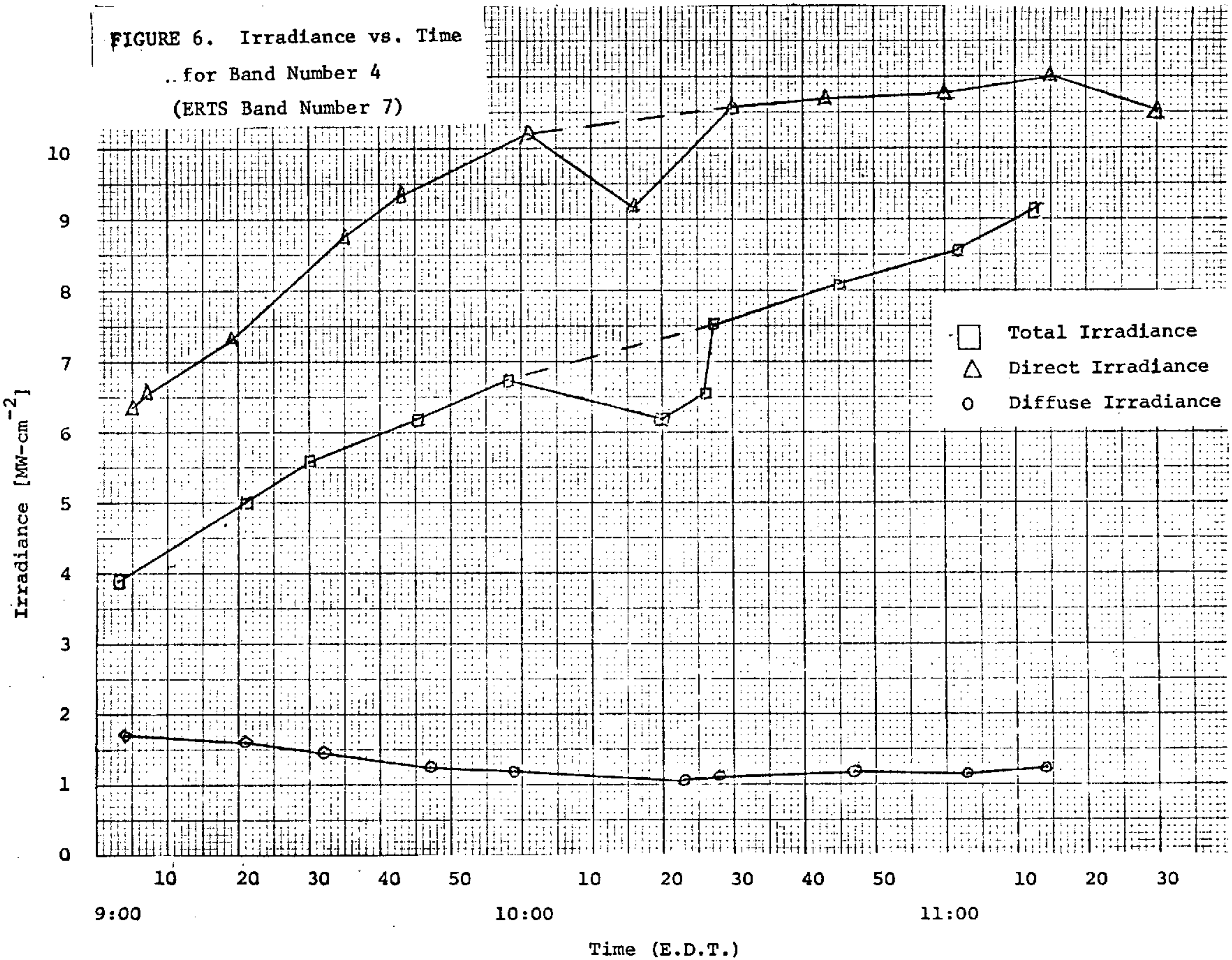


FIGURE 6. Irradiance vs. Time for Band Number 4 (ERTS Band Number 7)

Table I

RPMI Data Tabulation for 8-5-73 - Williamston Test Site

LOCAL TIME	COMMENTS	MEASUREMENTS	MSS BAND 1	2	3	4
9:03		E TOTAL	3.31	4.18	4.39	3.90
9:04		E DIFF	2.59	2.77	2.57	1.70
9:05		E DIR	2.06	4.09	5.27	6.36
9:07		E DIR	2.06	4.13	5.33	6.56
9:08	A/C Pass 1 Mi. West					
9:19		E DIR	2.91	5.31	6.41	7.33
9:21		E TOT	4.07	5.14	5.37	5.01
9:21	A/C Pass N-S 1Mi West	E DIFF	2.82	2.69	2.39	1.61
9:30		E TOT	4.47	5.71	5.94	5.59
9:32		E DIFF	2.73	2.54	2.21	1.47
9:35		E DIR	4.11	6.89	8.10	8.77
9:40	A/C Pass 2Mi East					
9:43		E DIR	4.83	7.74	8.84	9.35
9:45		E TOT	5.05	6.39	6.62	6.17
9:47		E DIFF	2.59	2.29	1.93	1.27
9:53	A/C 1 Mi. East 5kft					
9:58		E TOT	5.63	7.06	7.29	6.75
9:59		E DIFF	2.41	2.18	1.82	1.22
10:01		E DIR	5.72	8.81	9.86	10.22
10:15	REZERO					

Irradiance Values Given In milliwats-cm^{-2}

Radiance Values Given In milliwatts-cm^{-2}-ster^{-1}

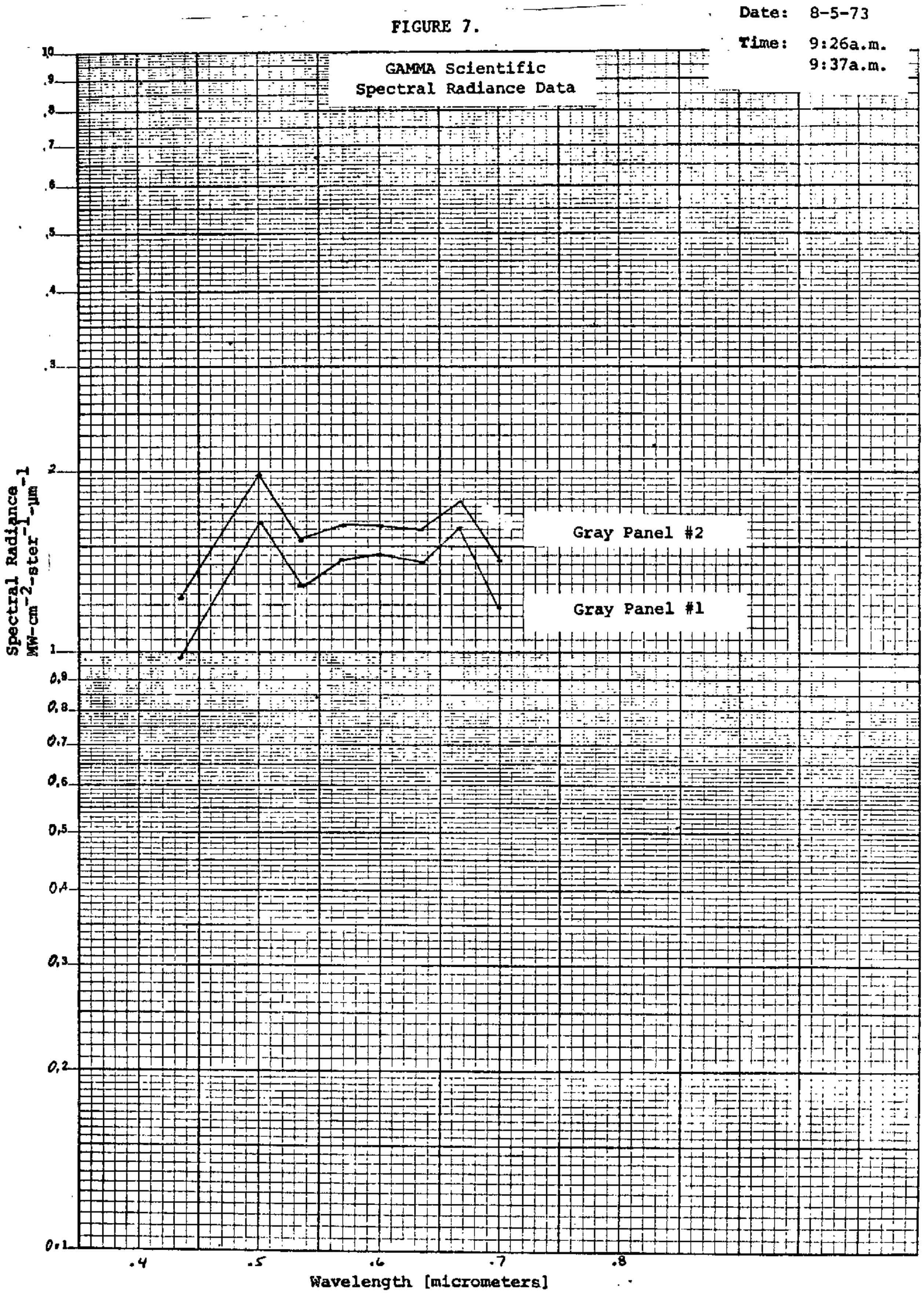
Table I Con't.

LOCAL TIME	COMMENTS	MEASUREMENTS	MSS BAND 1	2	3	4
10:16		E DIR	5.77	8.65	9.38	9.16
10:20		E TOT	5.95	7.29	7.29	6.17
10:23		E DIFF	2.30	2.03	1.70	1.06
10:26	10ktf. A/C REZERO x1 more offset than x03	E TOT	6.21	7.63	7.56	6.56
10:27		E TOT	6.53	8.14	8.24	7.52
10:28		E DIFF	2.24	1.99	1.67	1.12
10:30		E DIR	6.71	9.78	10.60	10.60
10:43		E DIR	6.71	9.78	10.60	10.70
10:45		E TOT	7.06	8.76	8.91	8.10
10:47		E DIFF	2.32	2.10	1.78	1.20
10:48		L (0)	.70	.63	.52	.36
11:00		E DIR	6.97	9.94	10.73	10.80
11:01	A/C 2kft.					
11:02		E TOT	7.42	9.15	9.32	8.58
11:03		E DIFF	2.32	2.06	1.72	1.16
11:04		L (0)	.72	.63	.52	.35
11:12	A/C N-S 1000 ft					
11:13		E TOT	7.96	9.83	9.92	9.16
11:14		E DIFF	2.59	2.31	1.90	1.27
11:15		L (0)	.87	.82	.69	.49
		E DIR	6.97	10.11	10.87	10.99
11:30	A/C 1k	E DIR	6.57	9.61	10.40	10.51

Irradiance Values Given In milliwatts-cm^{-2}

Radiance Values Given In milliwatts-cm^{-2}-ster^{-1}

FIGURE 7.

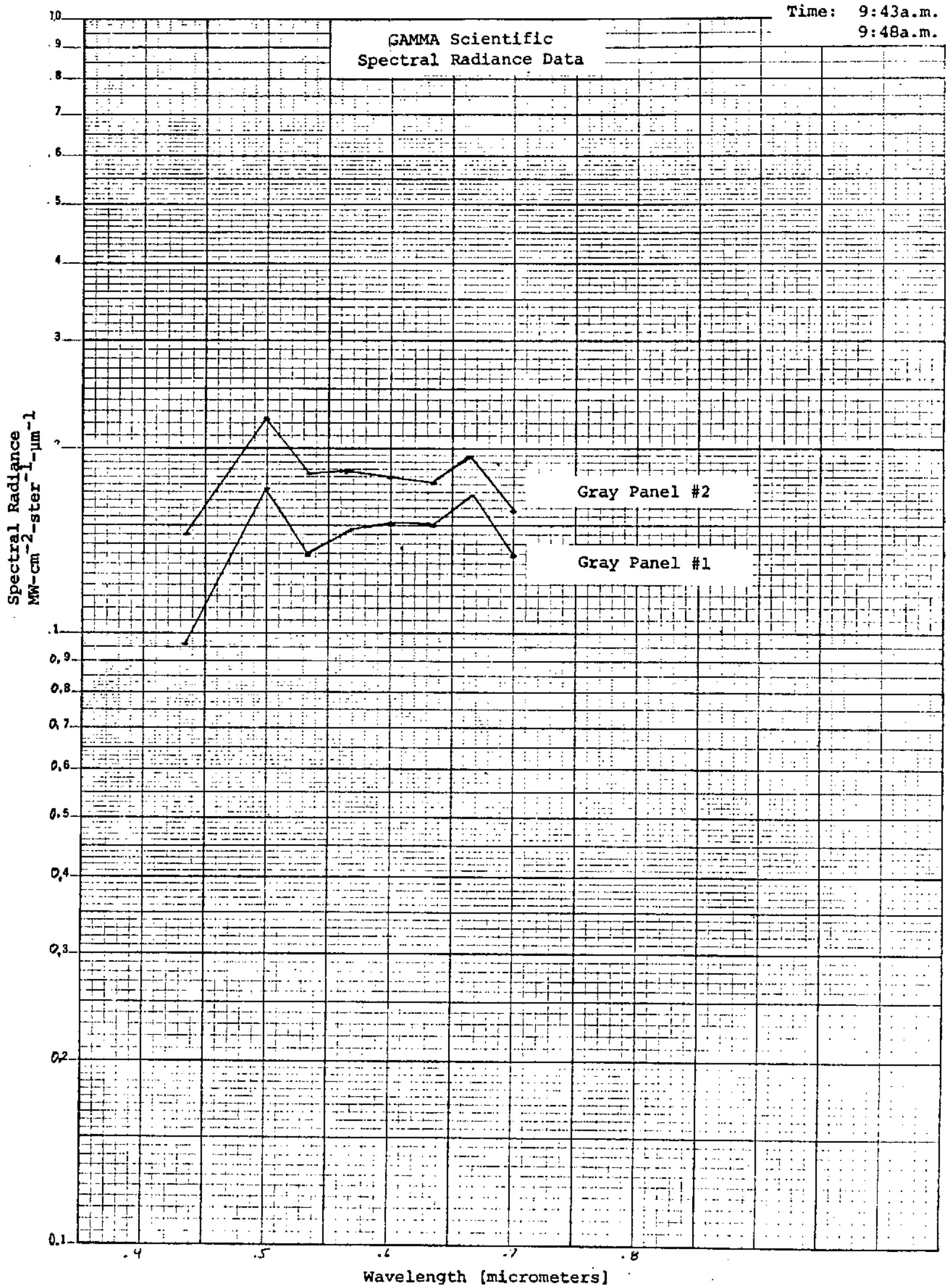


Date: 8-5-73
Time: 9:26a.m.
9:37a.m.
GAMMA Scientific
Spectral Radiance Data
Gray Panel #2
Gray Panel #1
Spectral Radiance
MW-cm-2-ster-1-µm-1
10
.9
.8
.7
.6
.5
.4
.3
2
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
.4
.5
.6
.7
.8
Wavelength [micrometers]

FIGURE 8.

Date: 8-5-73

Time: 9:43a.m.
9:48a.m.



Date: 8-5-73

Time: 10:24a.m.
10:30a.m.

FIGURE 9

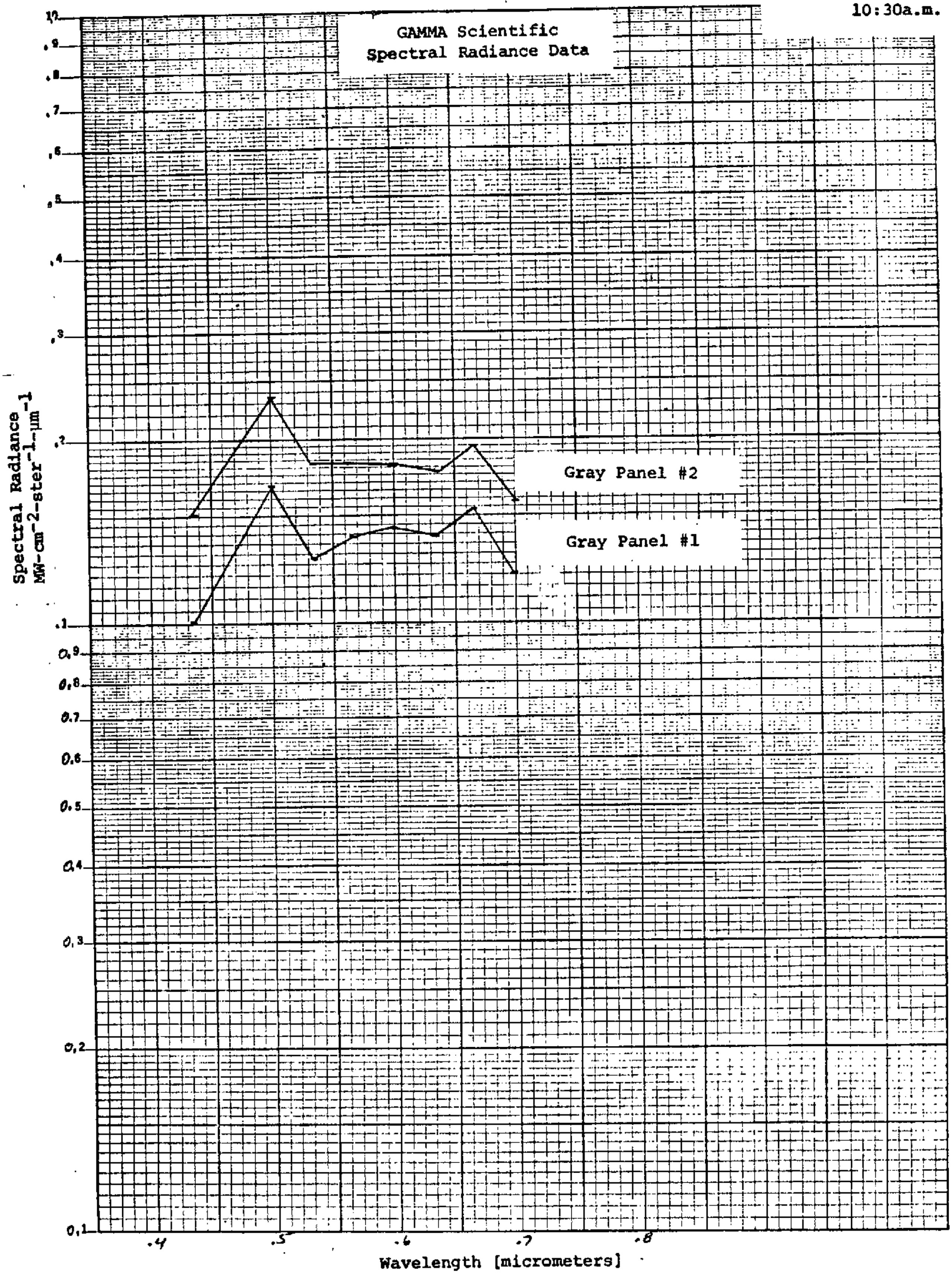
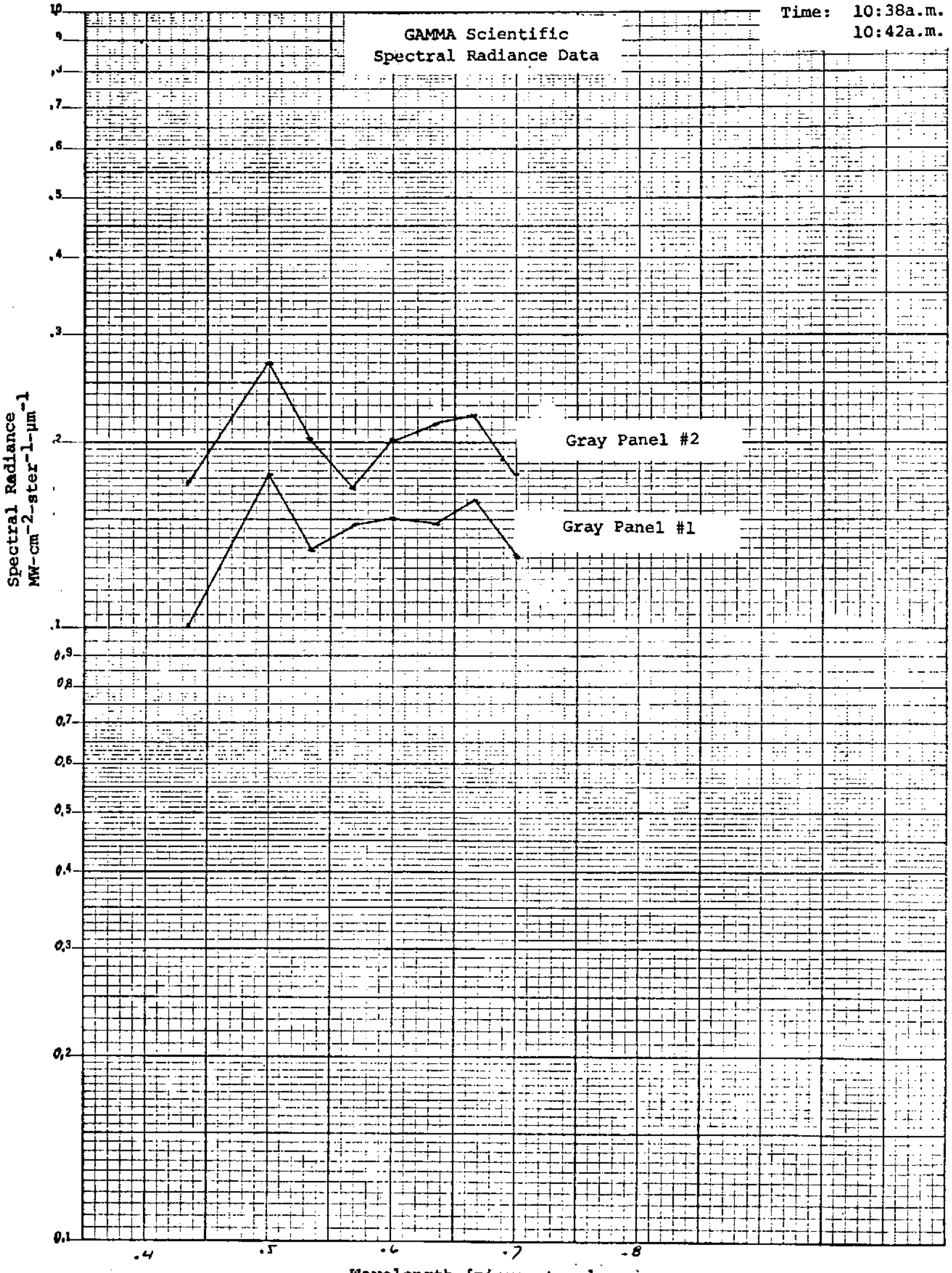


FIGURE 10.

Date: 8-5-73

Time: 10:38a.m.
10:42a.m.



Date: 8-5-73

FIGURE 11.

Time: 10:55a.m.

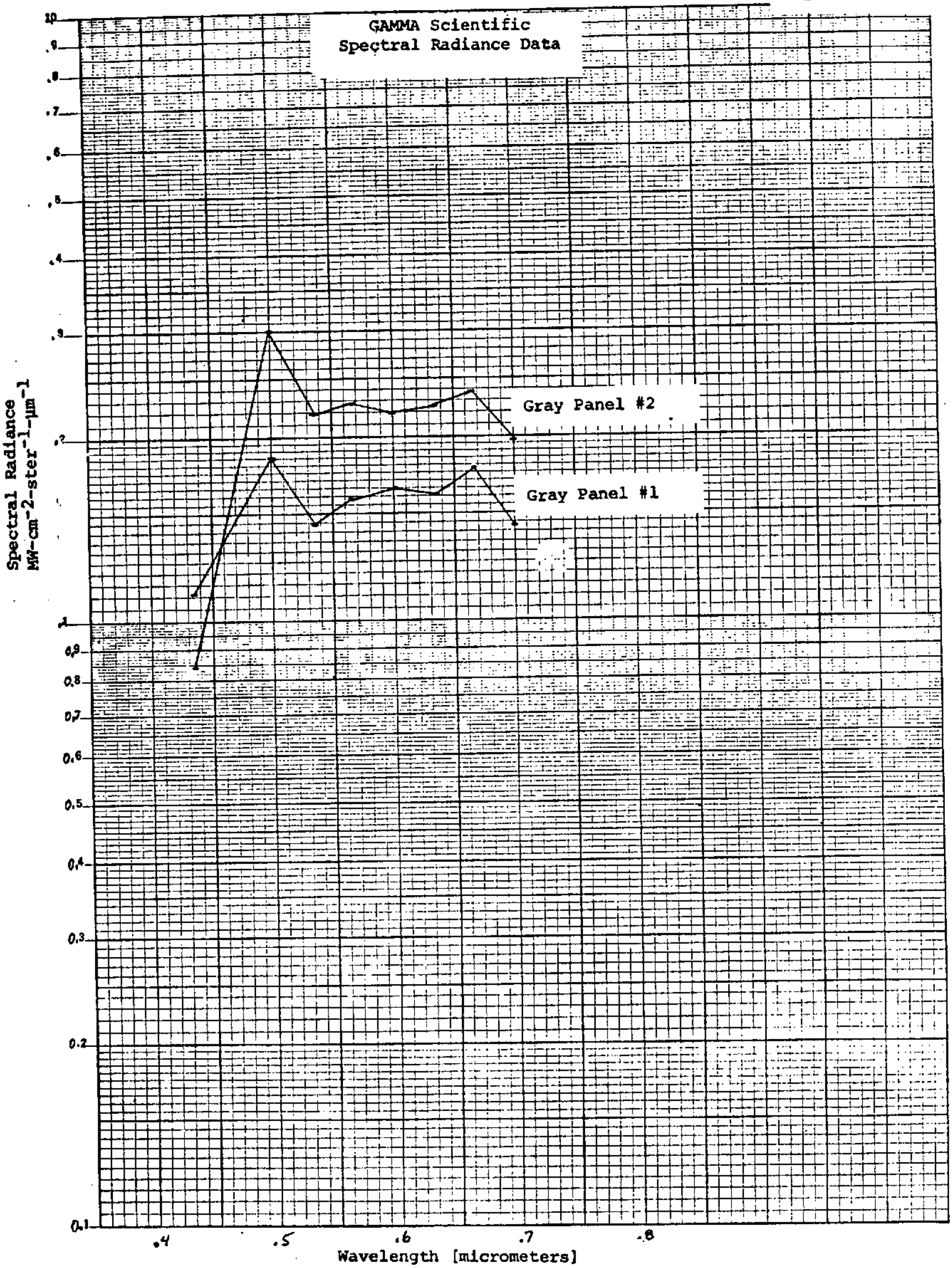
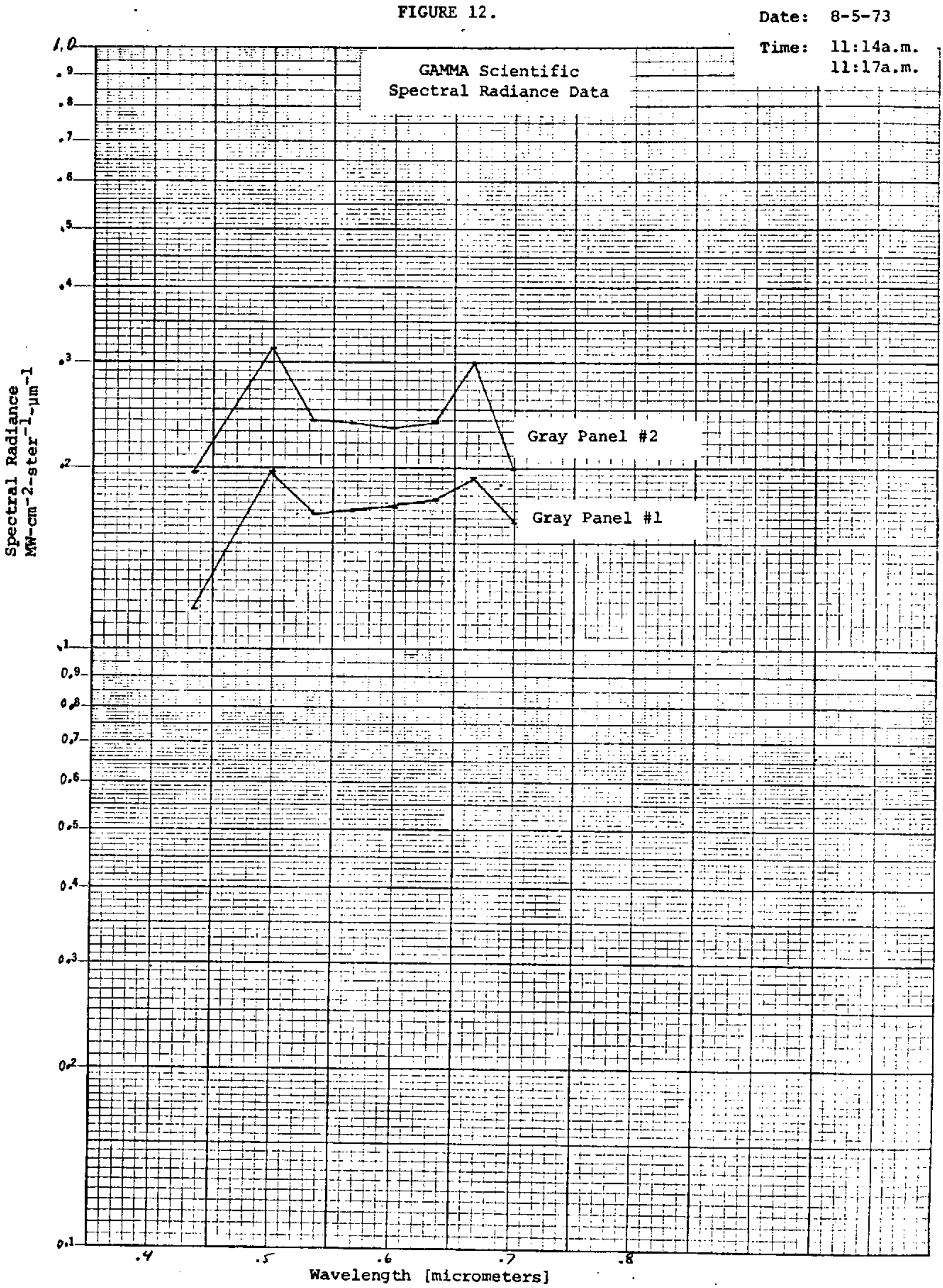


FIGURE 12.


Date: 8-5-73
Time: 11:14a.m.
11:17a.m.
GAMMA Scientific
Spectral Radiance Data
Gray Panel #2
Gray Panel #1
Spectral Radiance
MW-cm-2-ster-1-μm-1
Wavelength [micrometers]

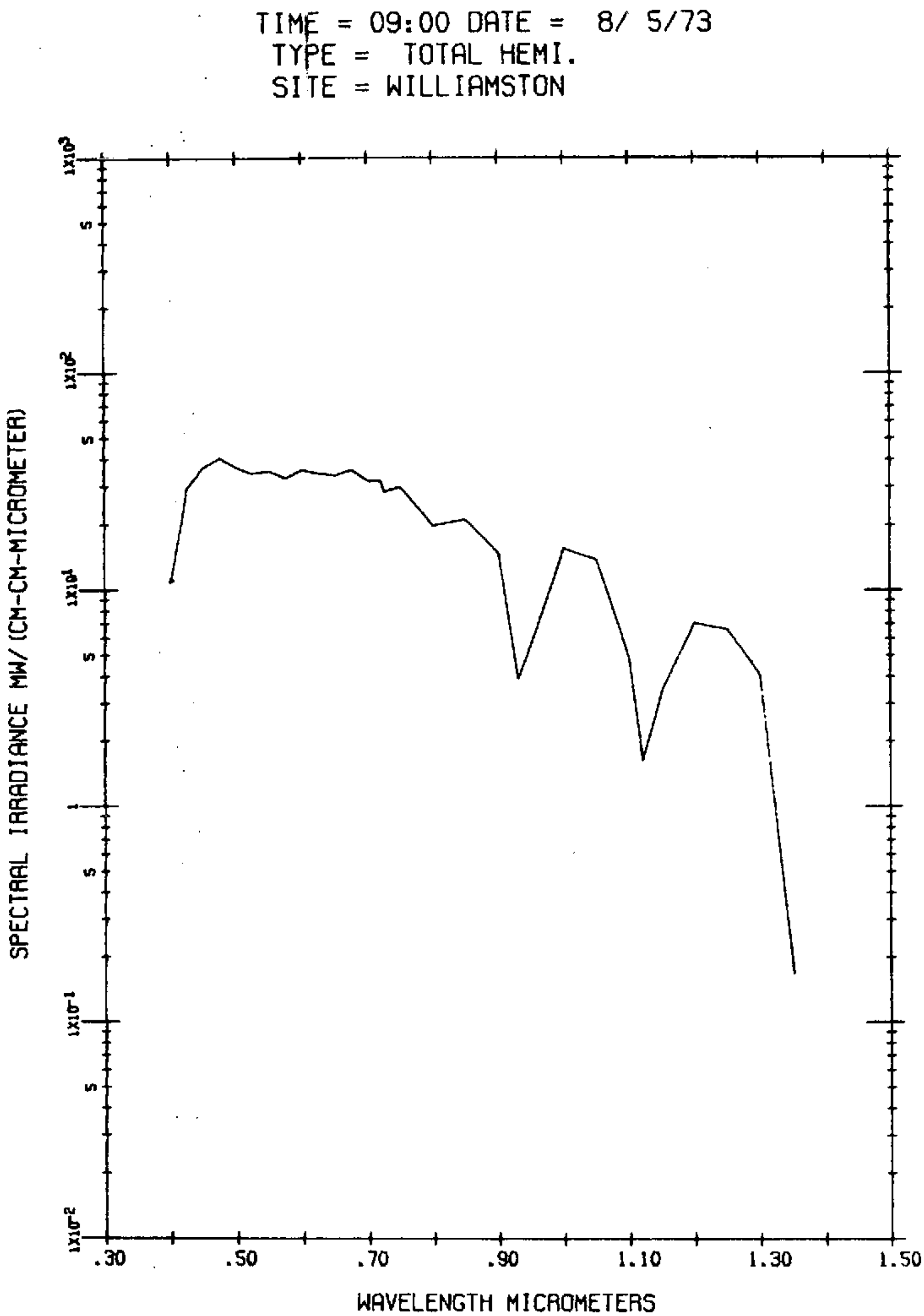


FIGURE 13. ISCO SPECTRAL IRRADIANCE DATA

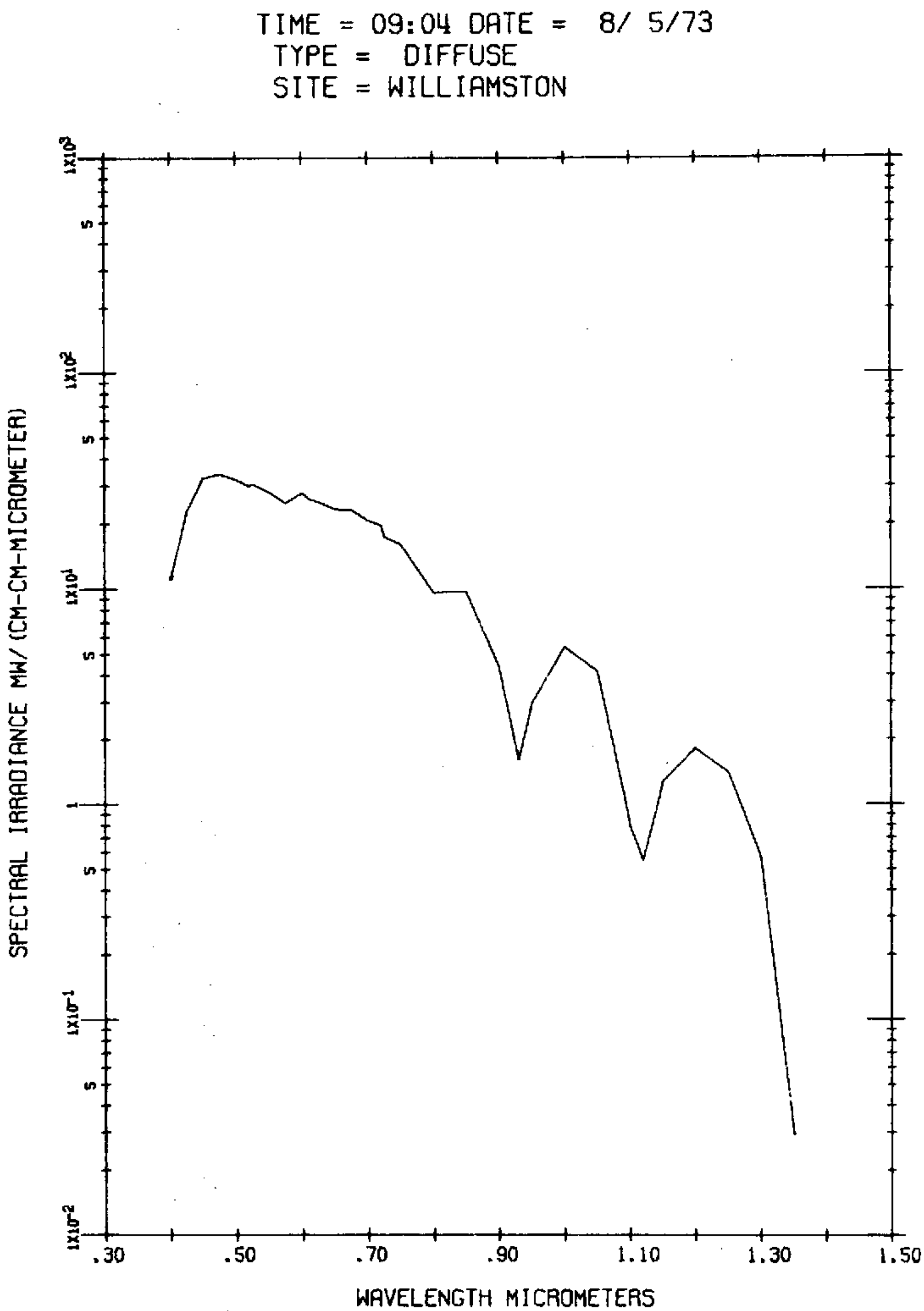


FIGURE 14. ISCO SPECTRAL IRRADIANCE DATA

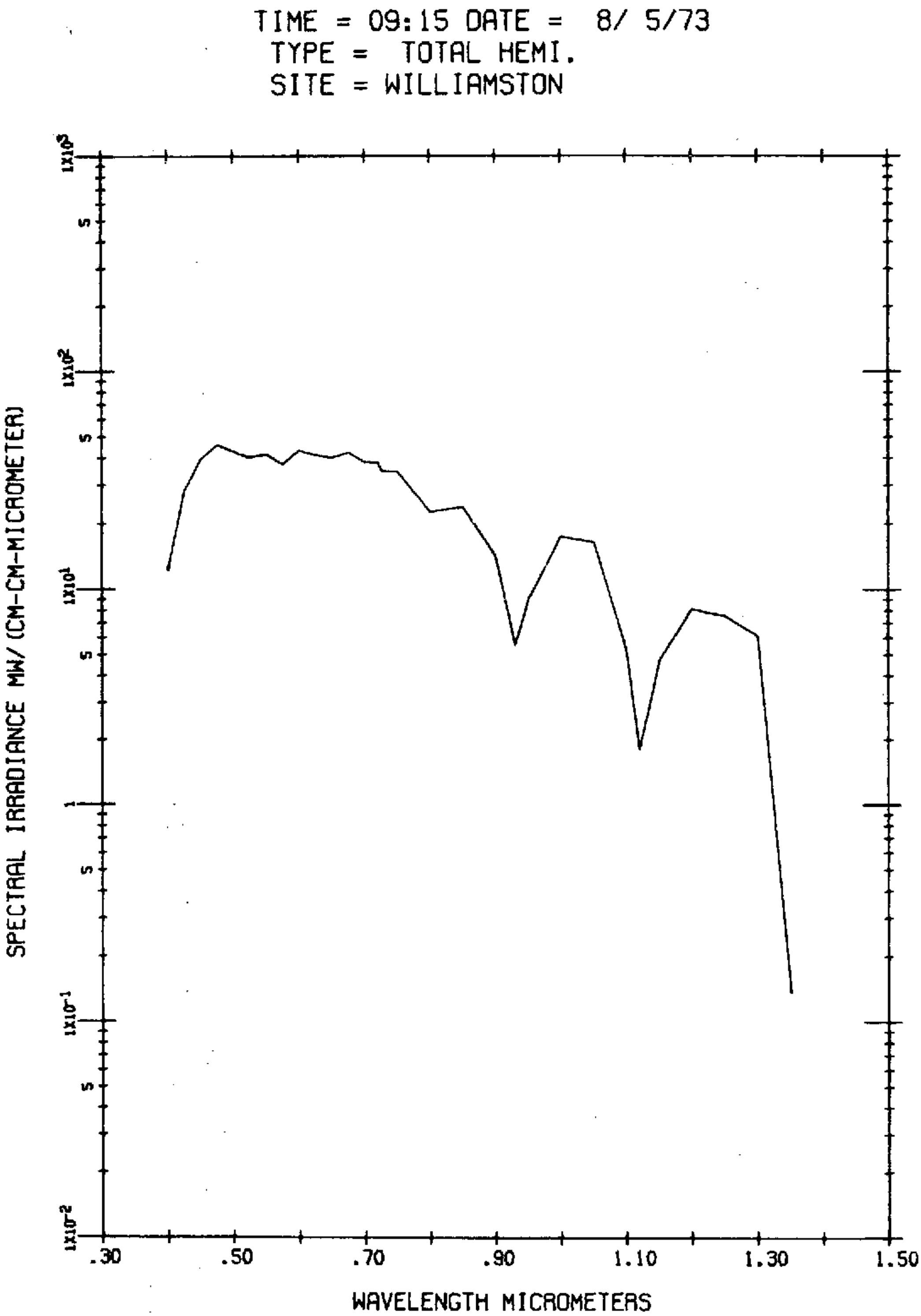


FIGURE 15. ISCO SPECTRAL IRRADIANCE DATA

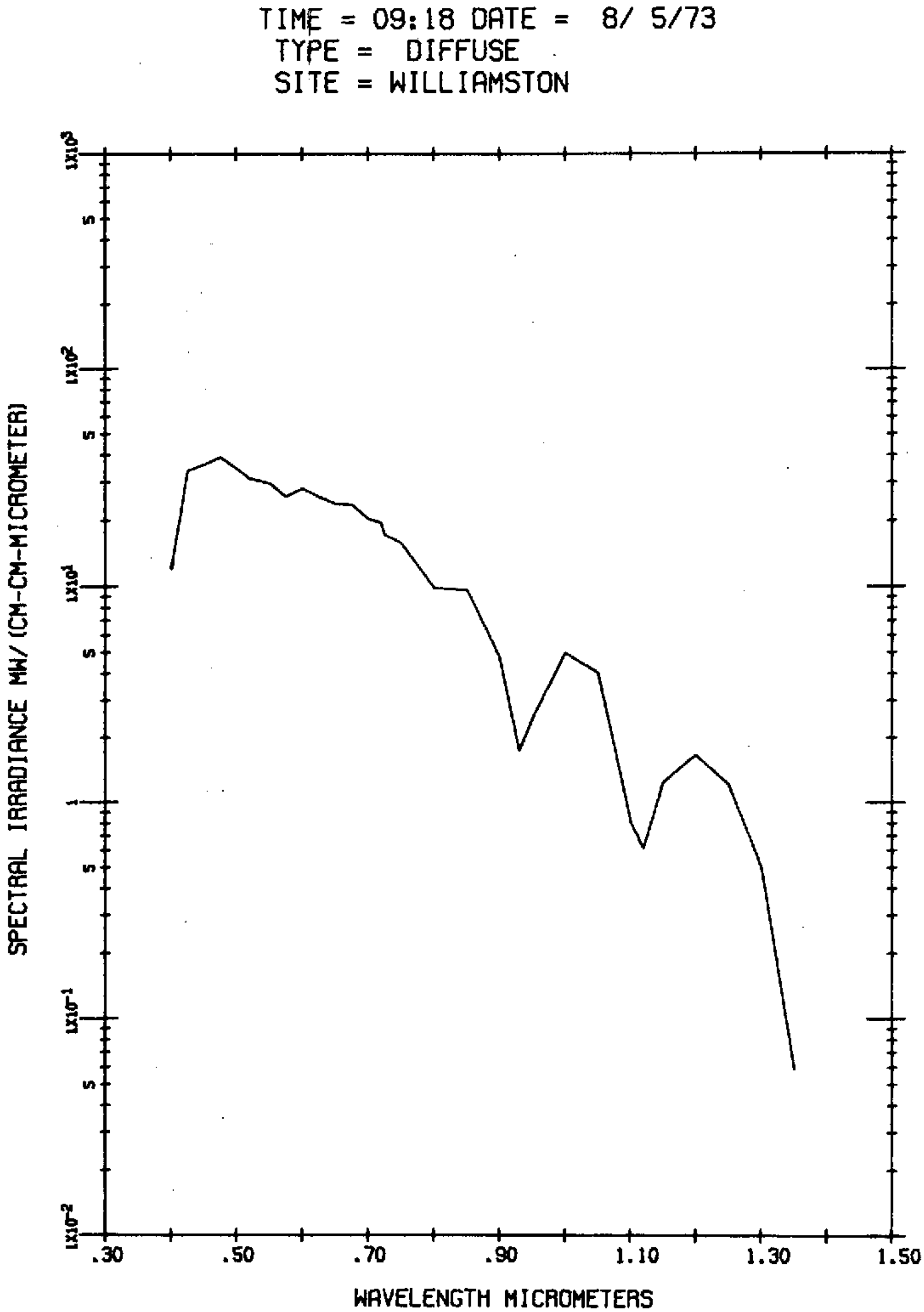


FIGURE 16. ISCO SPECTRAL IRRADIANCE DATA

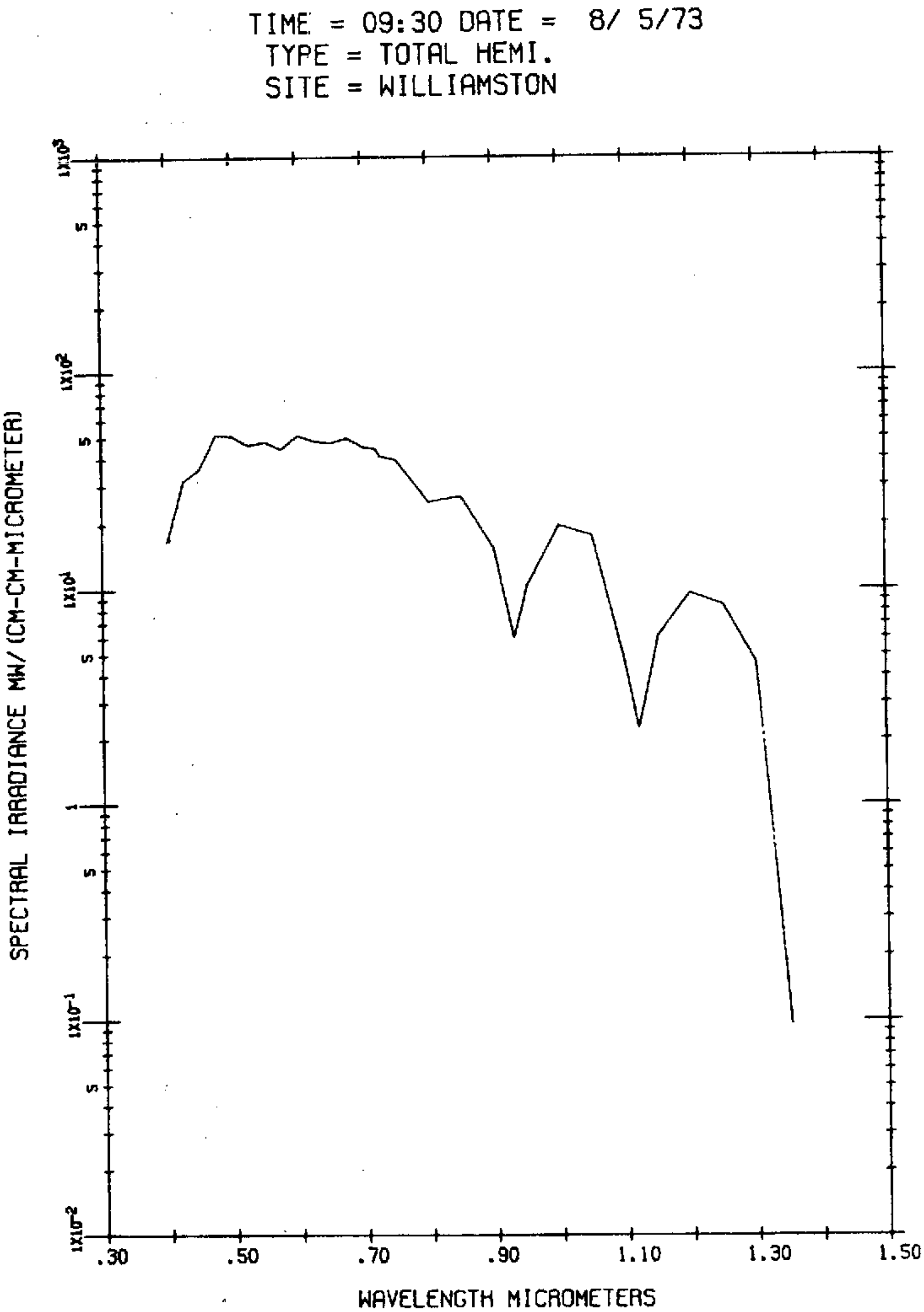


FIGURE 17. ISCO SPECTRAL IRRADIANCE DATA

TIME = 09:34 DATE = 8/ 5/73
TYPE = DIFFUSE
SITE = WILLIAMSTON

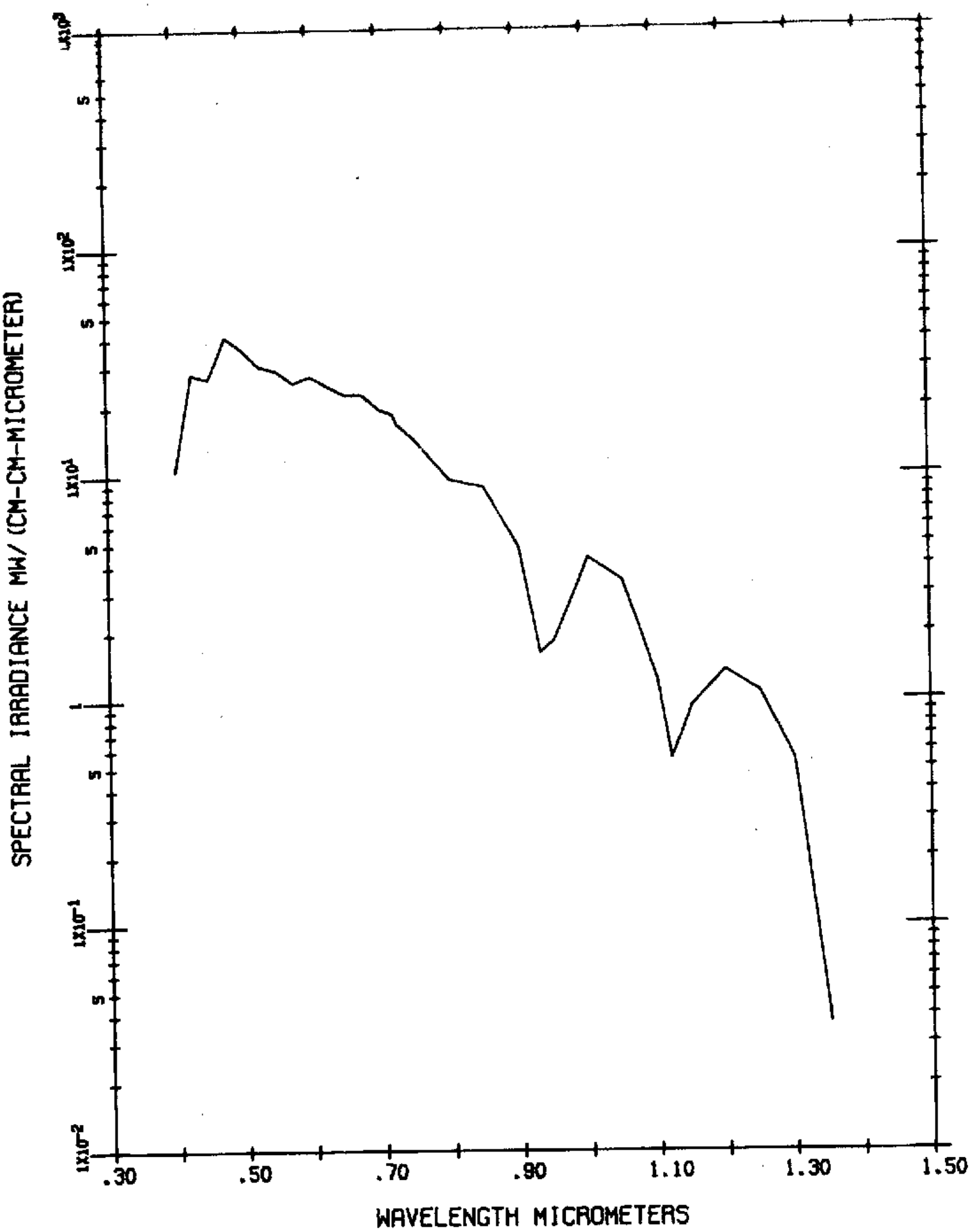


FIGURE 18. ISCO SPECTRAL IRRADIANCE DATA

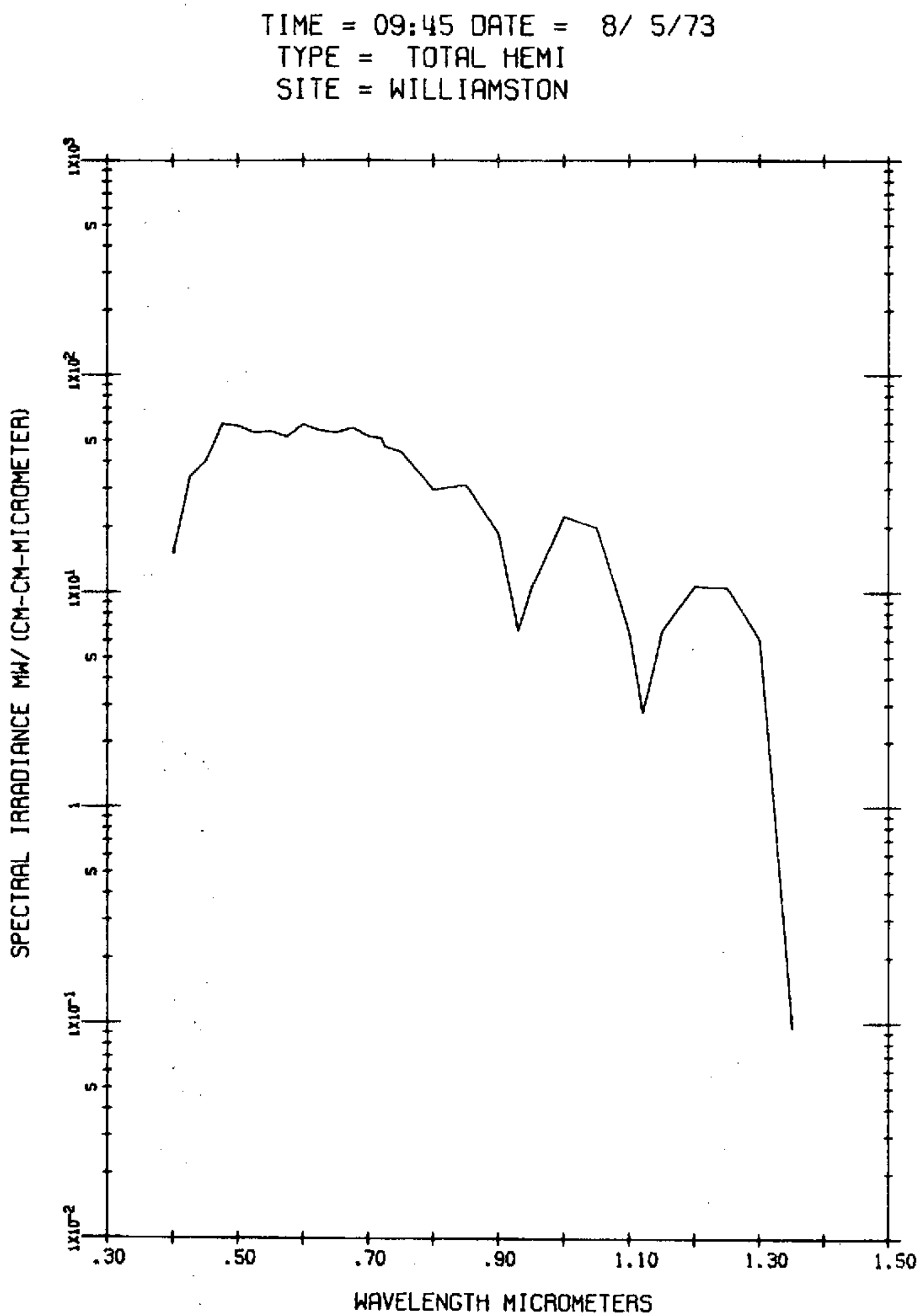


FIGURE 19. ISCO SPECTRAL IRRADIANCE DATA

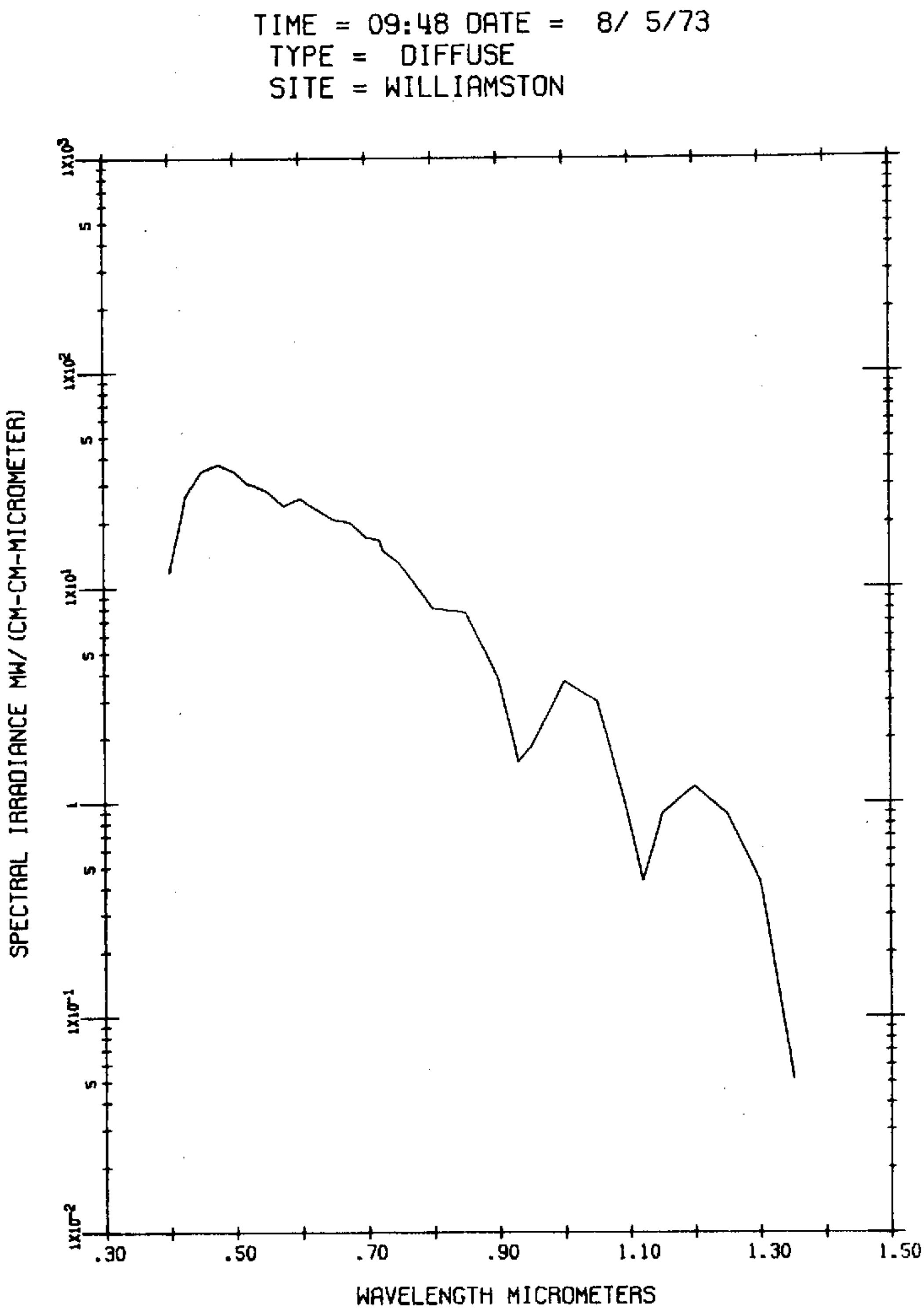


FIGURE 20. ISCO SPECTRAL IRRADIANCE DATA

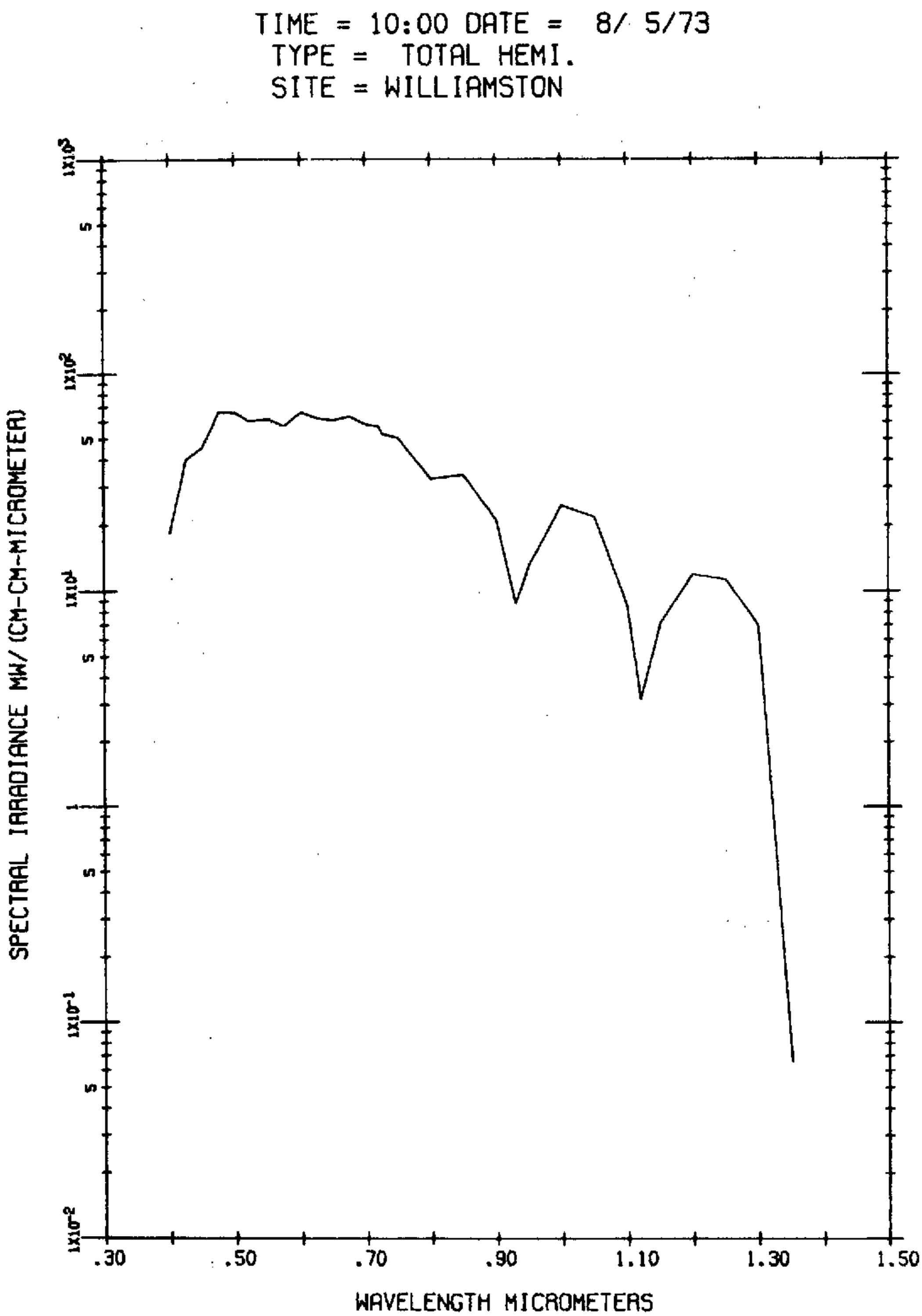


FIGURE 21. ISCO SPECTRAL IRRADIANCE DATA

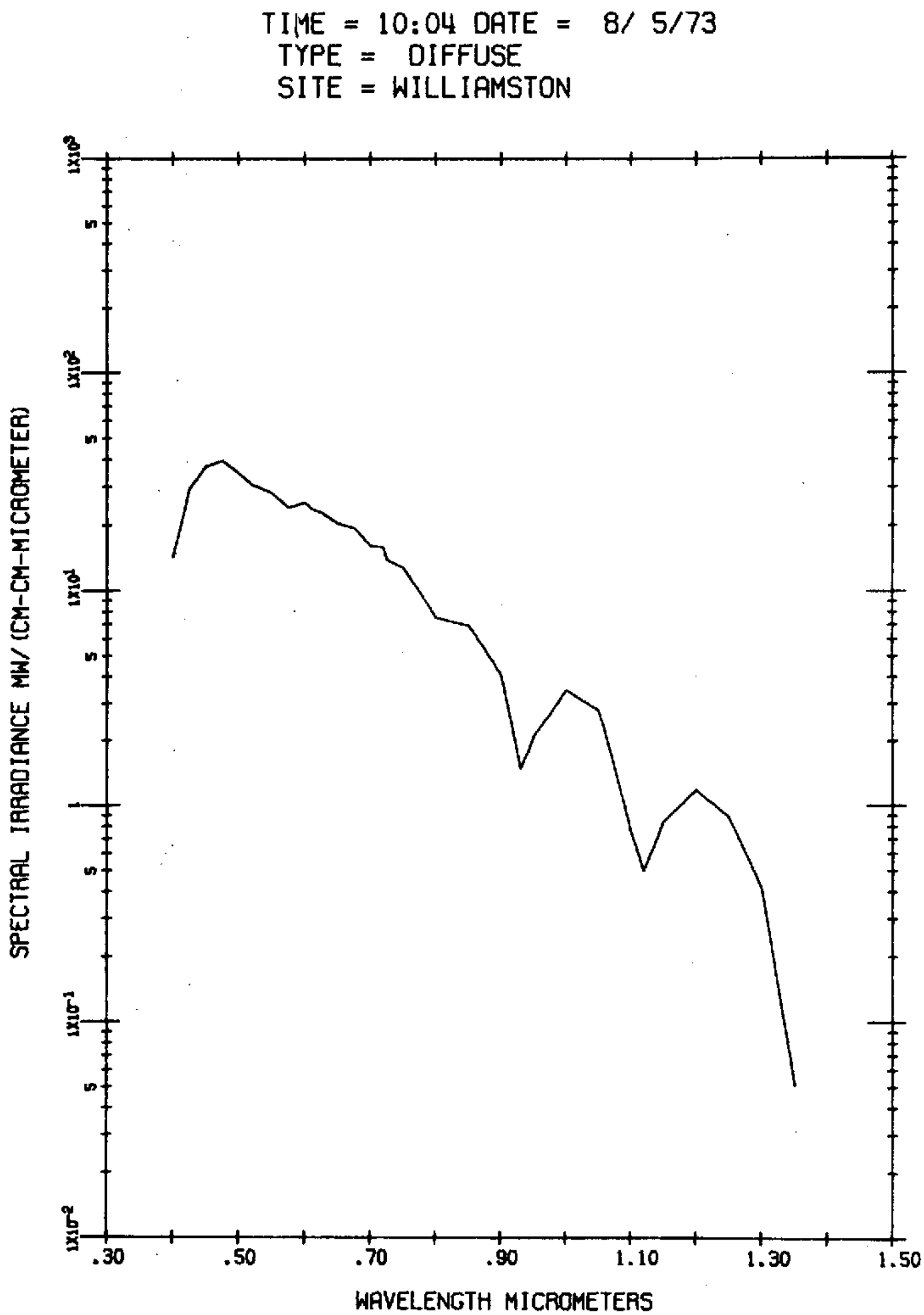


FIGURE 22. ISCO SPECTRAL IRRADIANCE DATA

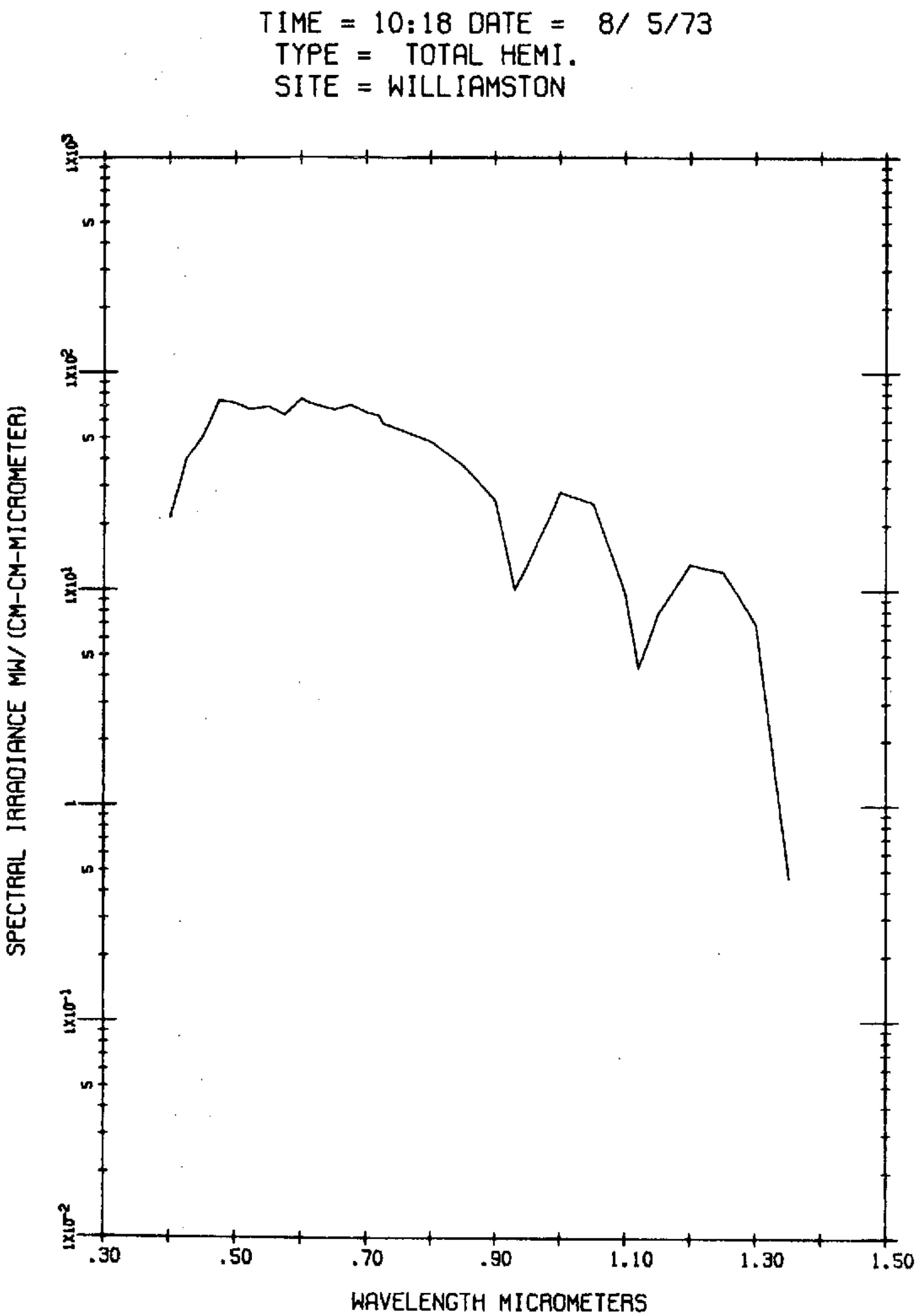


FIGURE 23. ISCO SPECTRAL IRRADIANCE DATA

TIME = 10:20 DATE = 8/ 5/73
TYPE = DIFFUSE
SITE = WILLIAMSTON

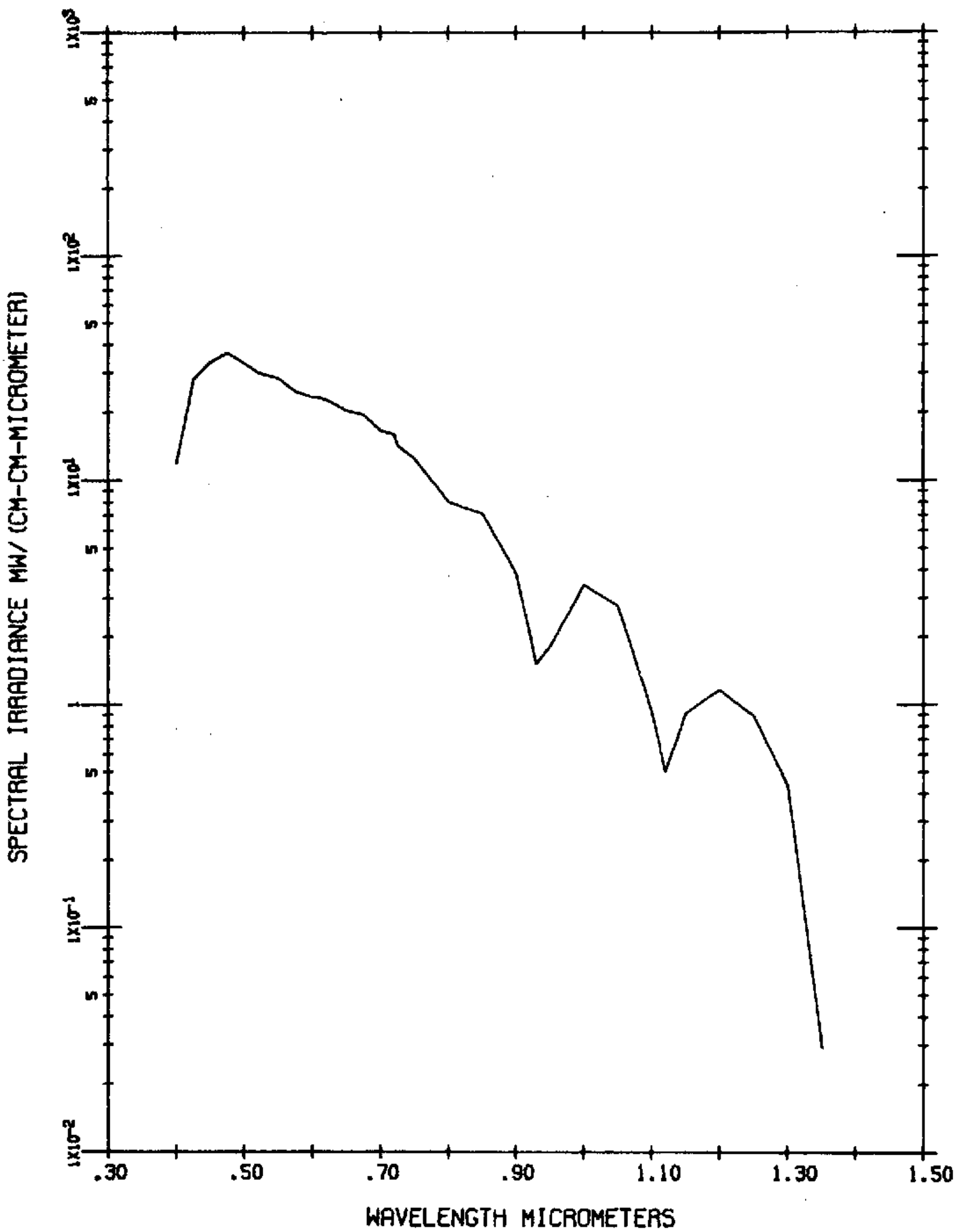


FIGURE 24. ISCO SPECTRAL IRRADIANCE DATA

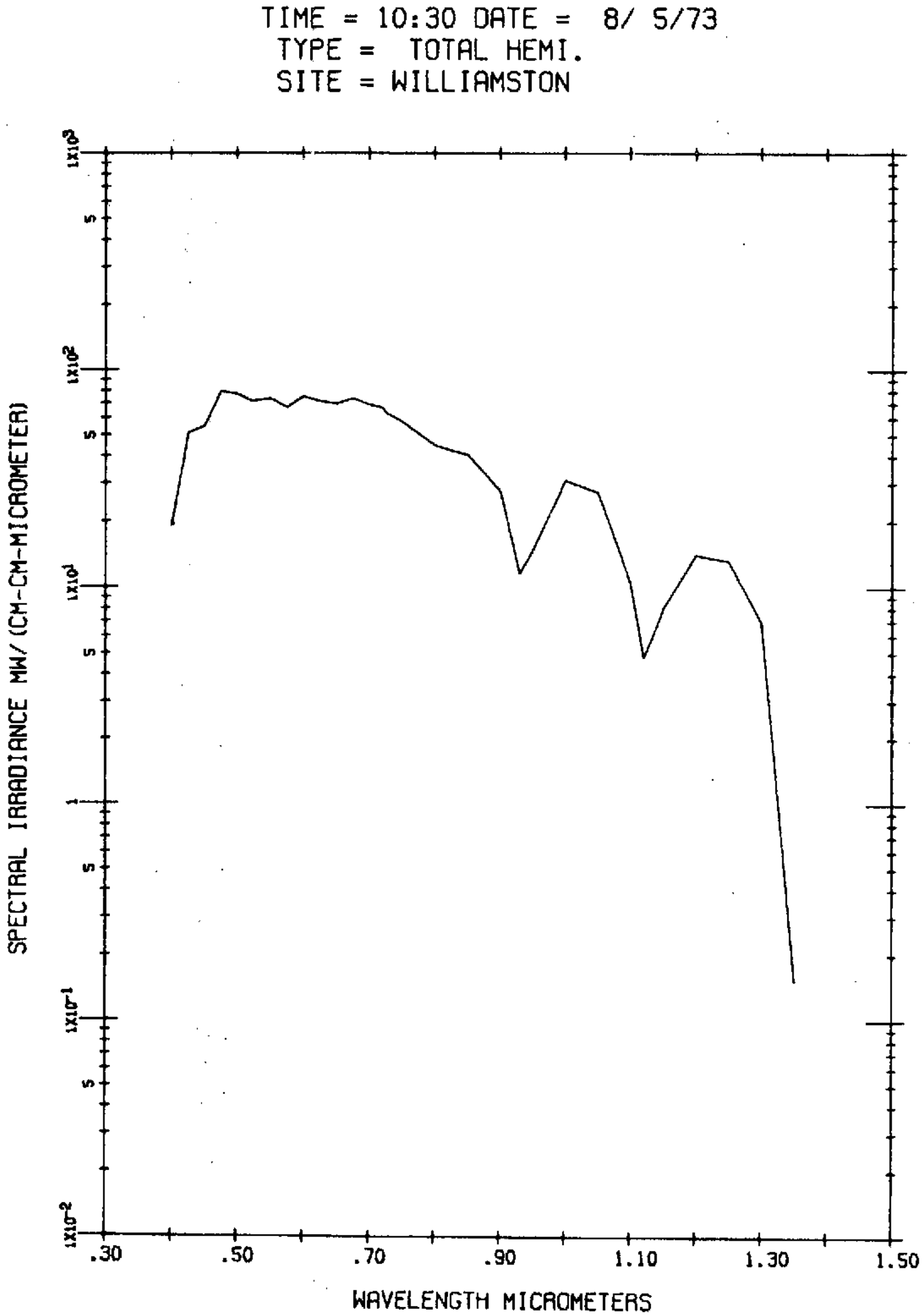


FIGURE 25. ISCO SPECTRAL IRRADIANCE DATA

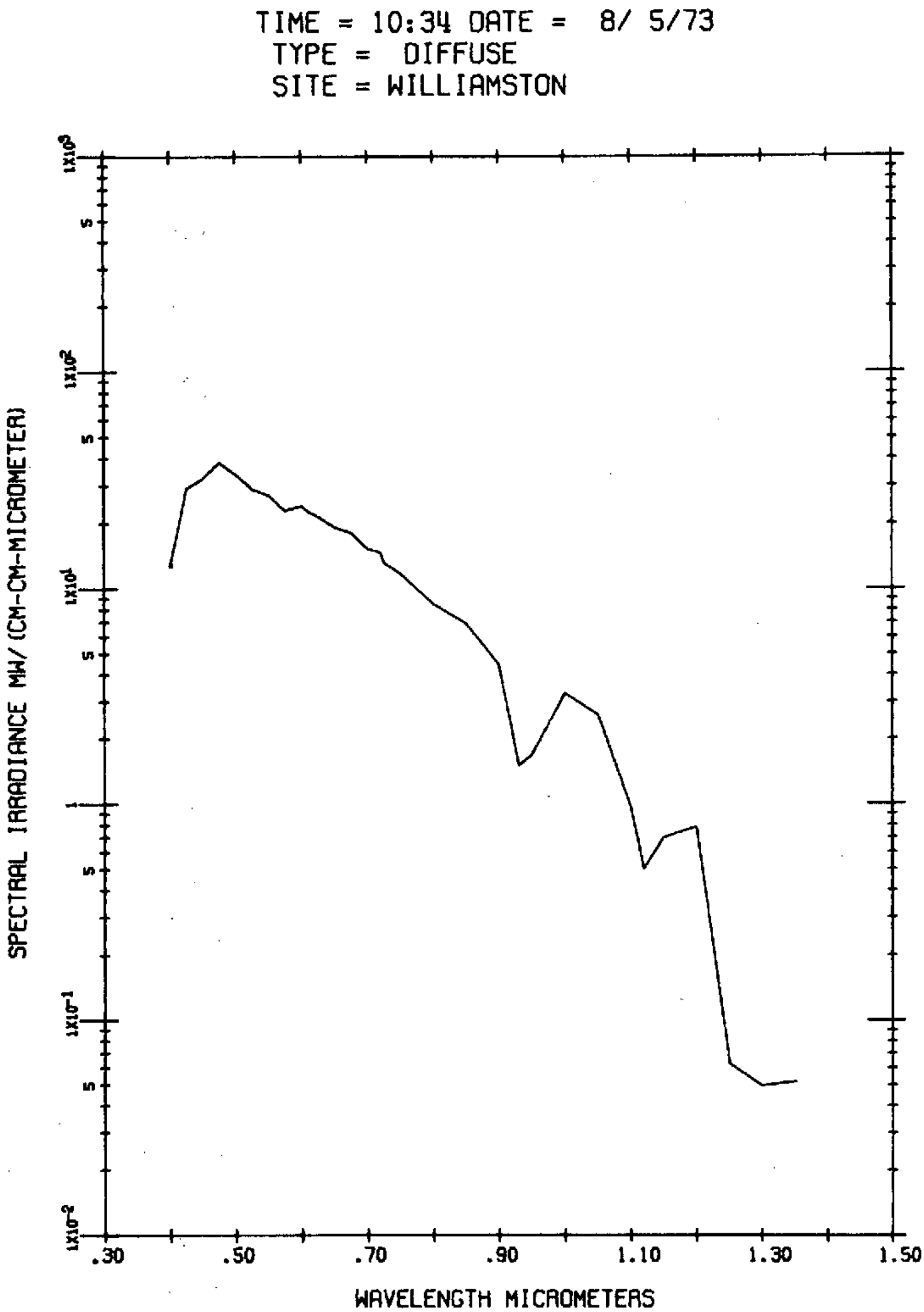


FIGURE 26. ISCO SPECTRAL IRRADIANCE DATA

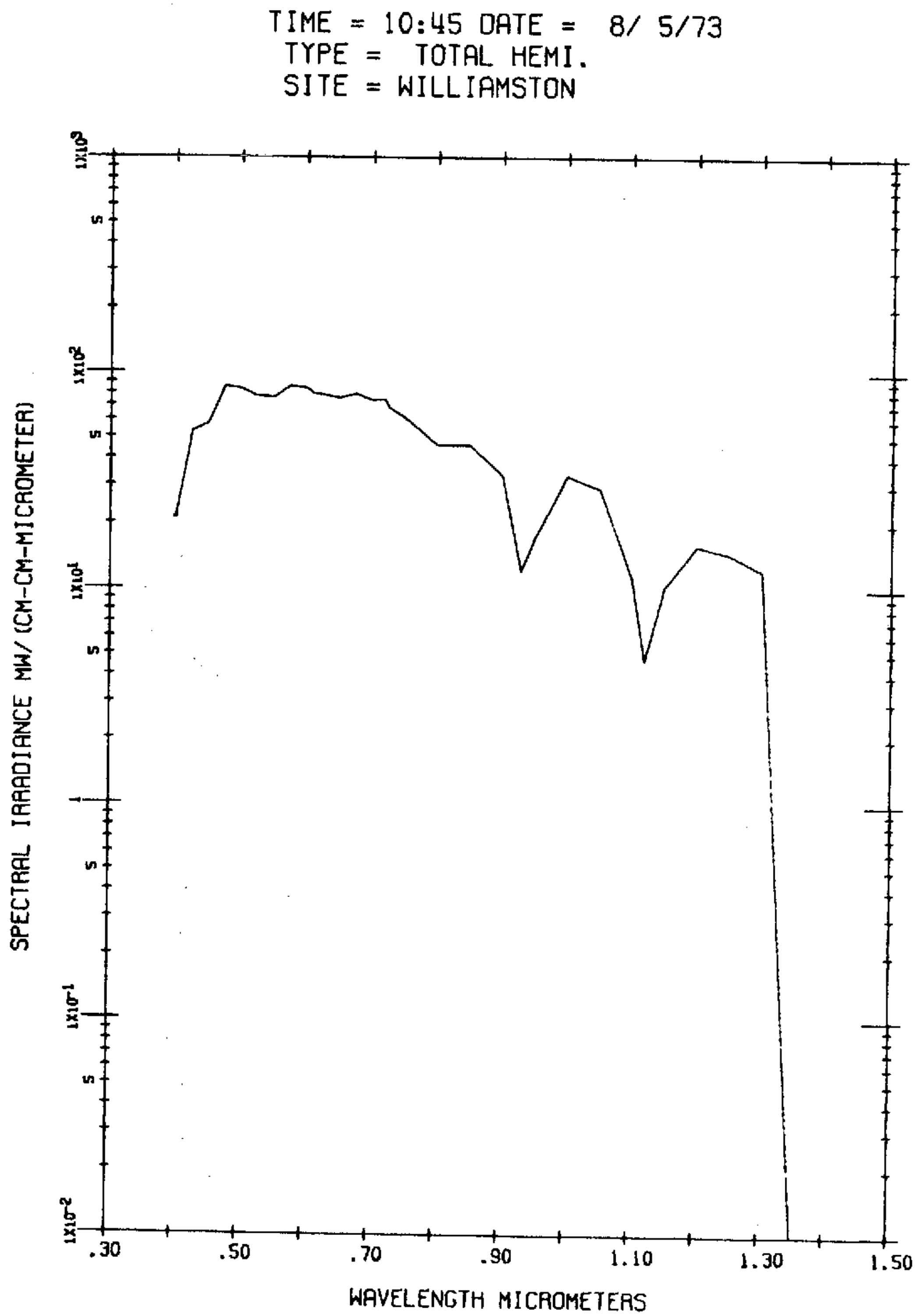


FIGURE 27. ISCO SPECTRAL IRRADIANCE DATA

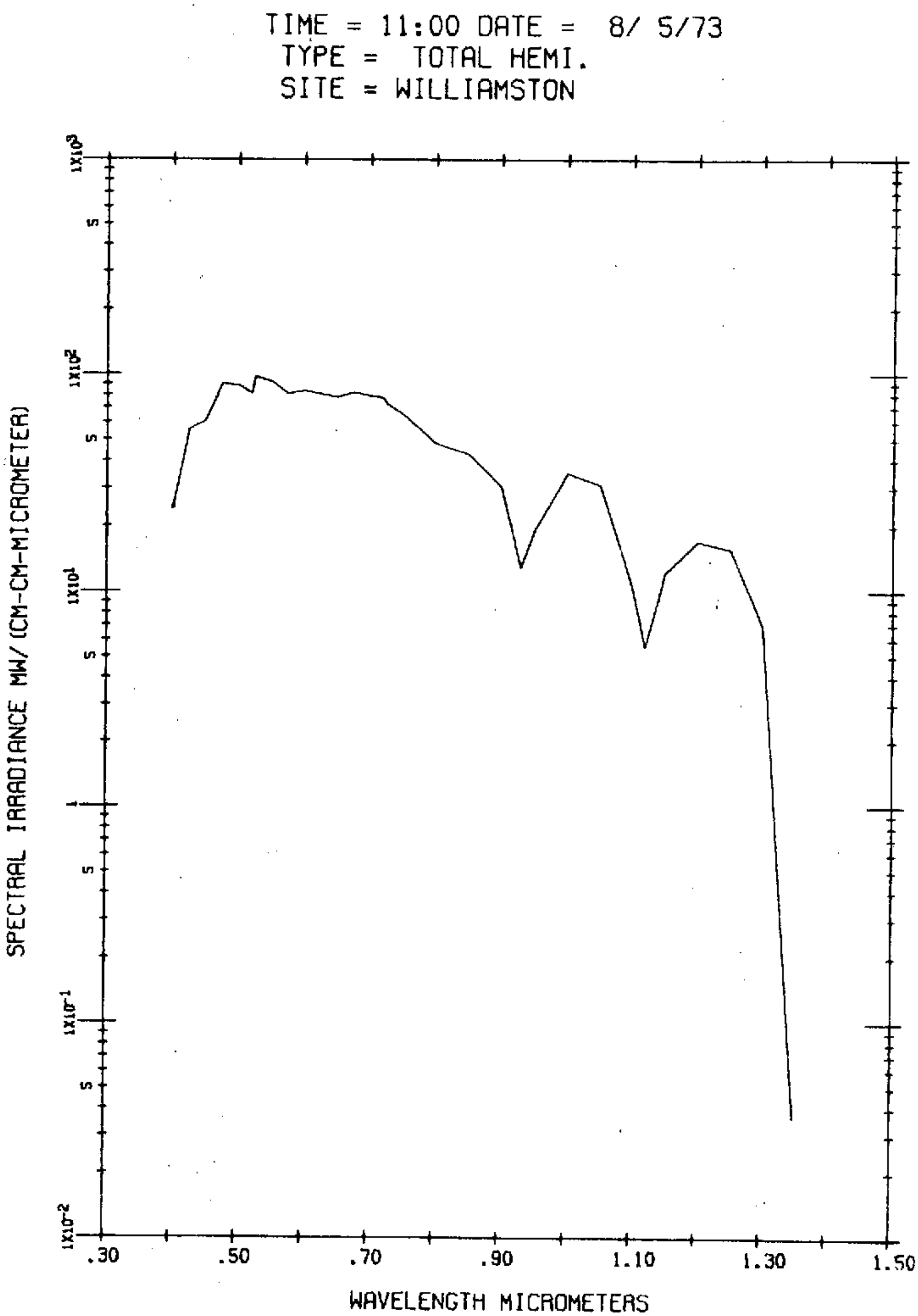


FIGURE 28. ISCO SPECTRAL IRRADIANCE DATA

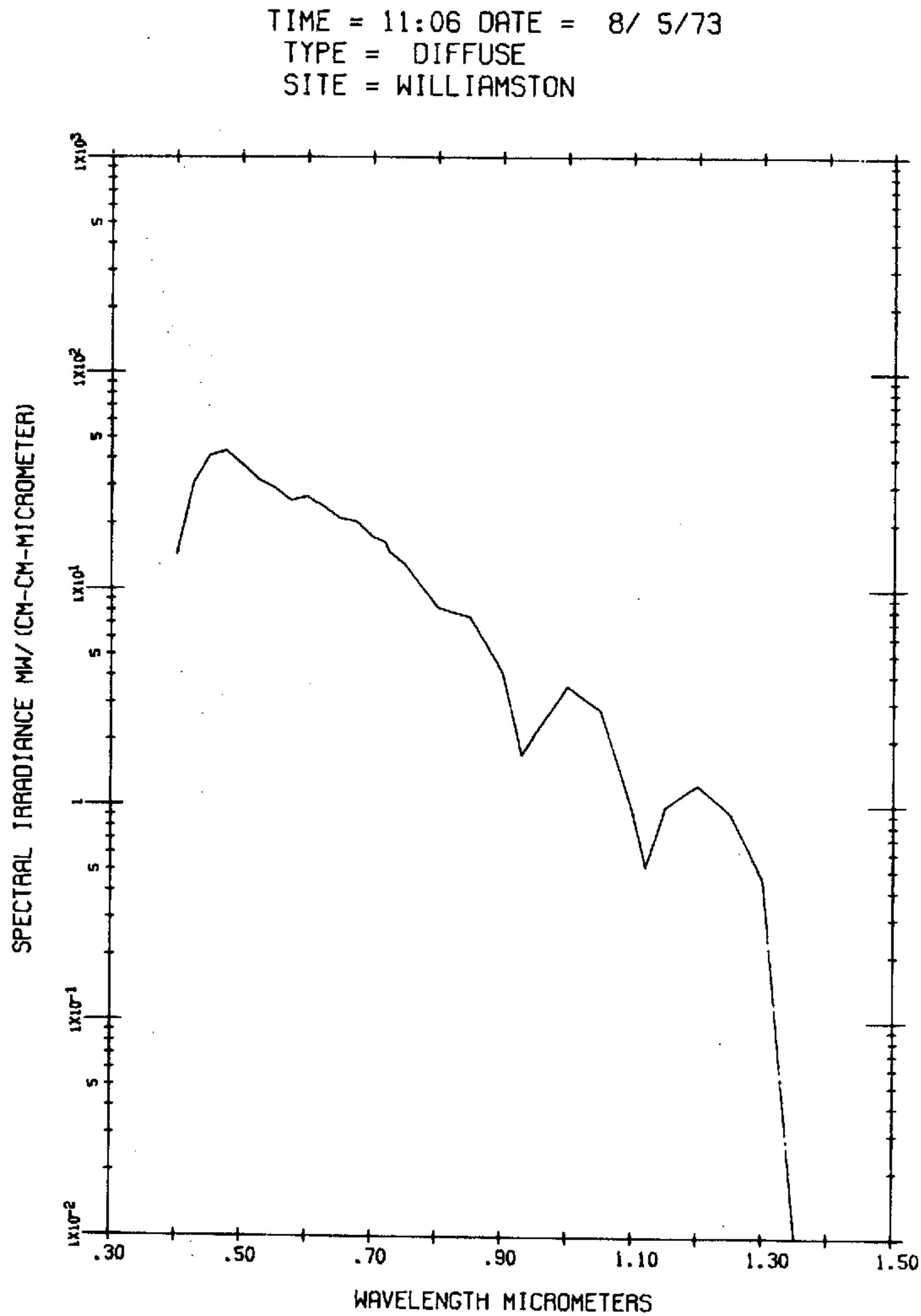


FIGURE 29. ISCO SPECTRAL IRRADIANCE DATA

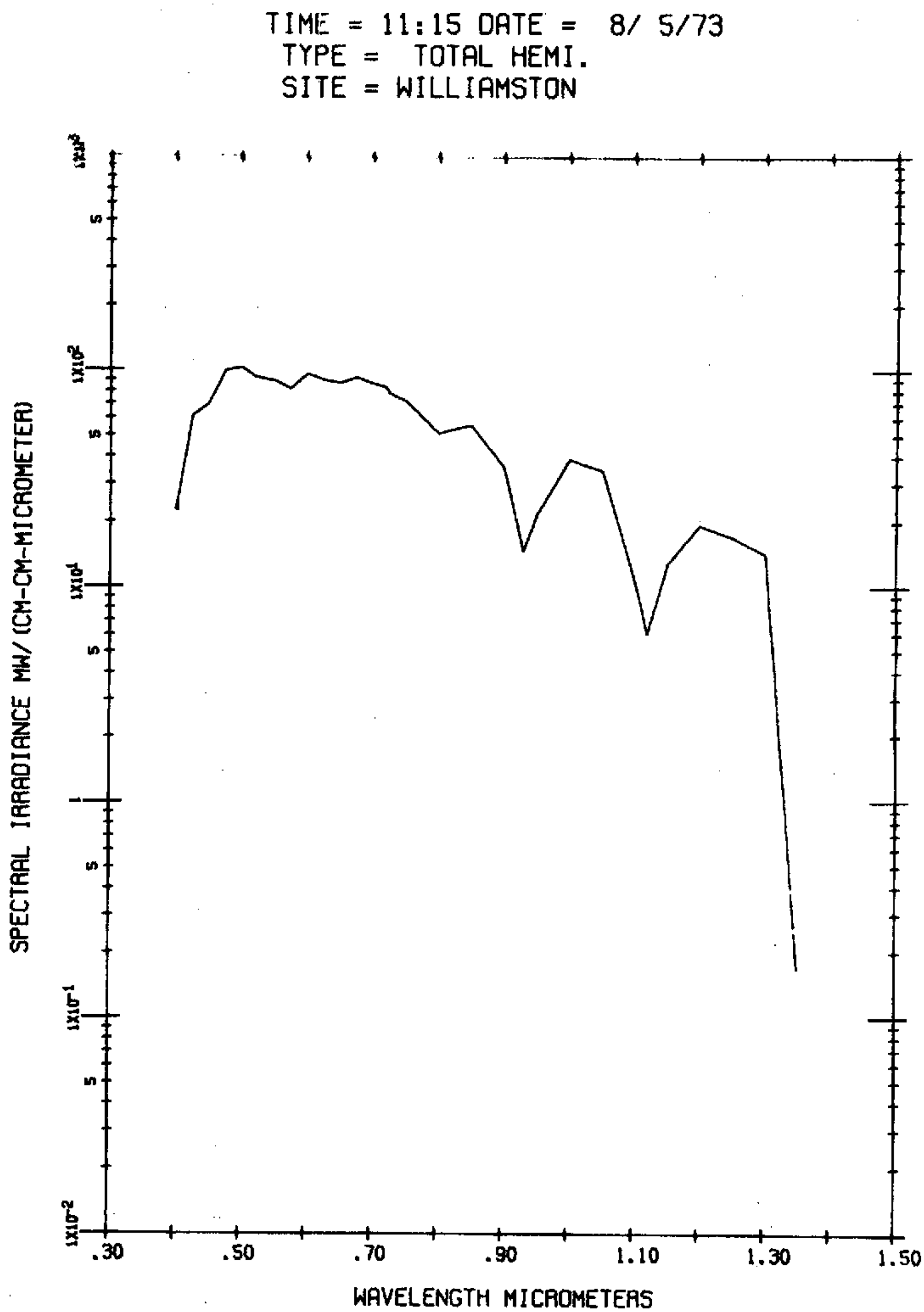


FIGURE 30. ISCO SPECTRAL IRRADIANCE DATA

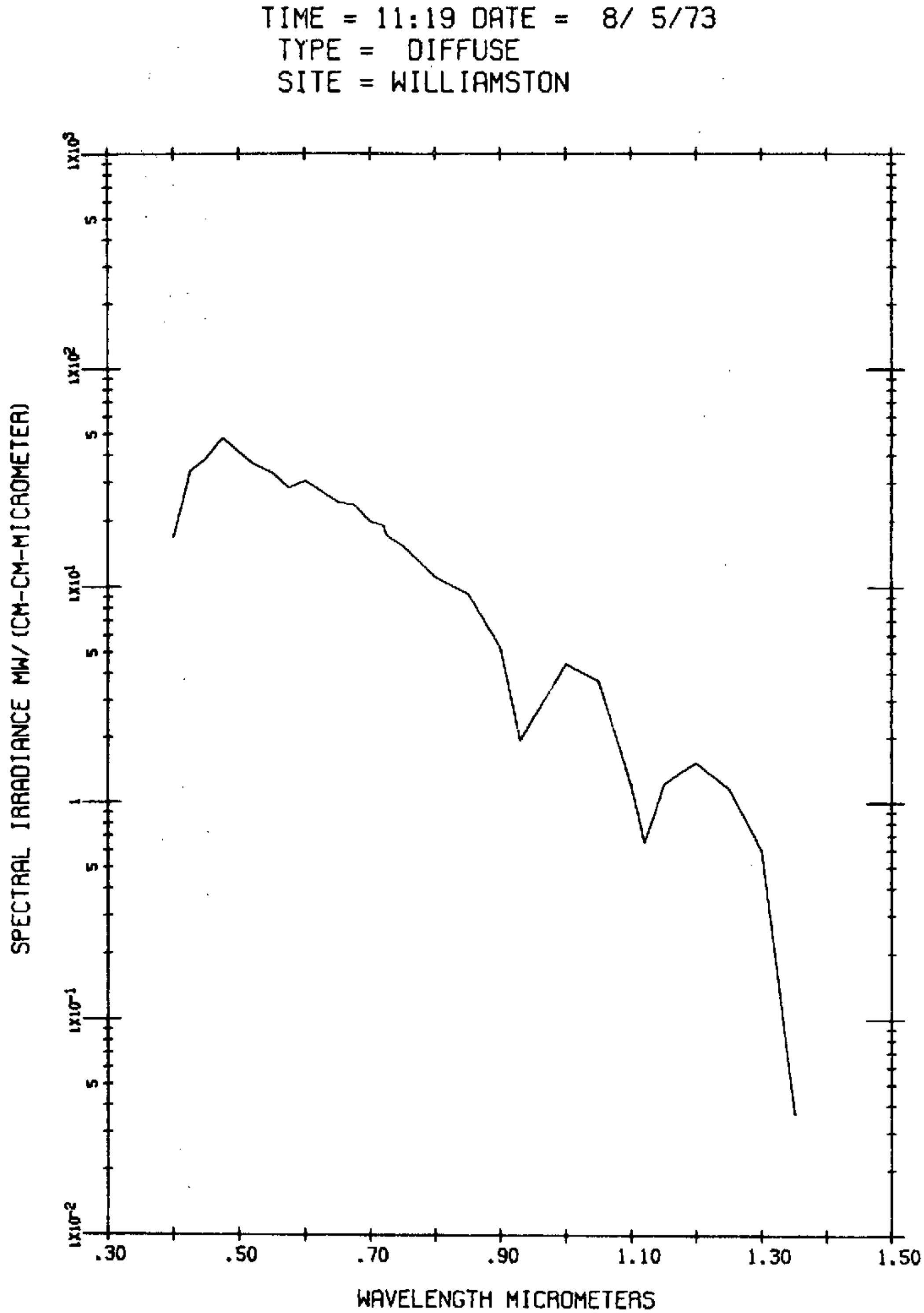


FIGURE 31. ISCO SPECTRAL IRRADIANCE DATA

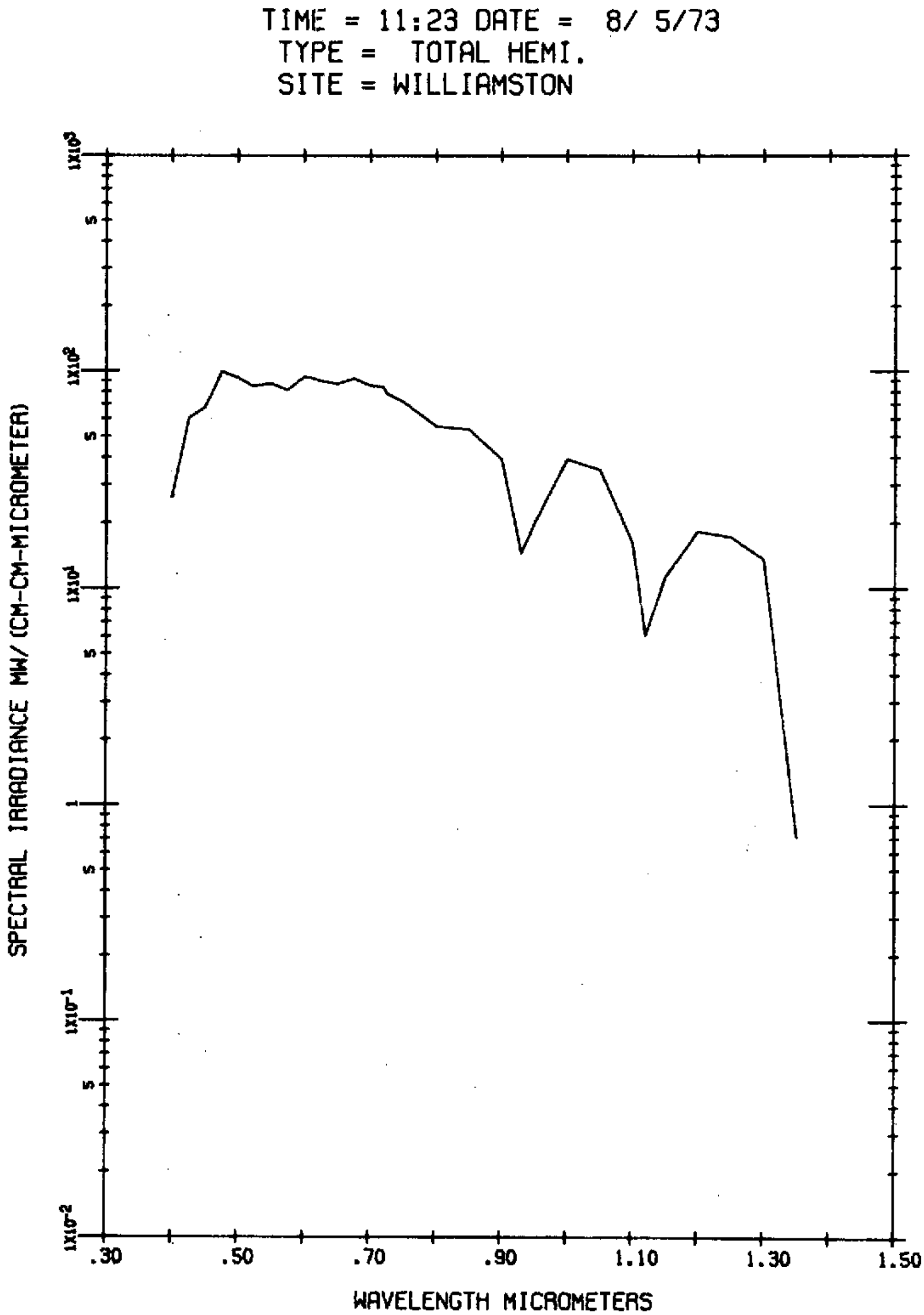


FIGURE 32. ISCO SPECTRAL IRRADIANCE DATA

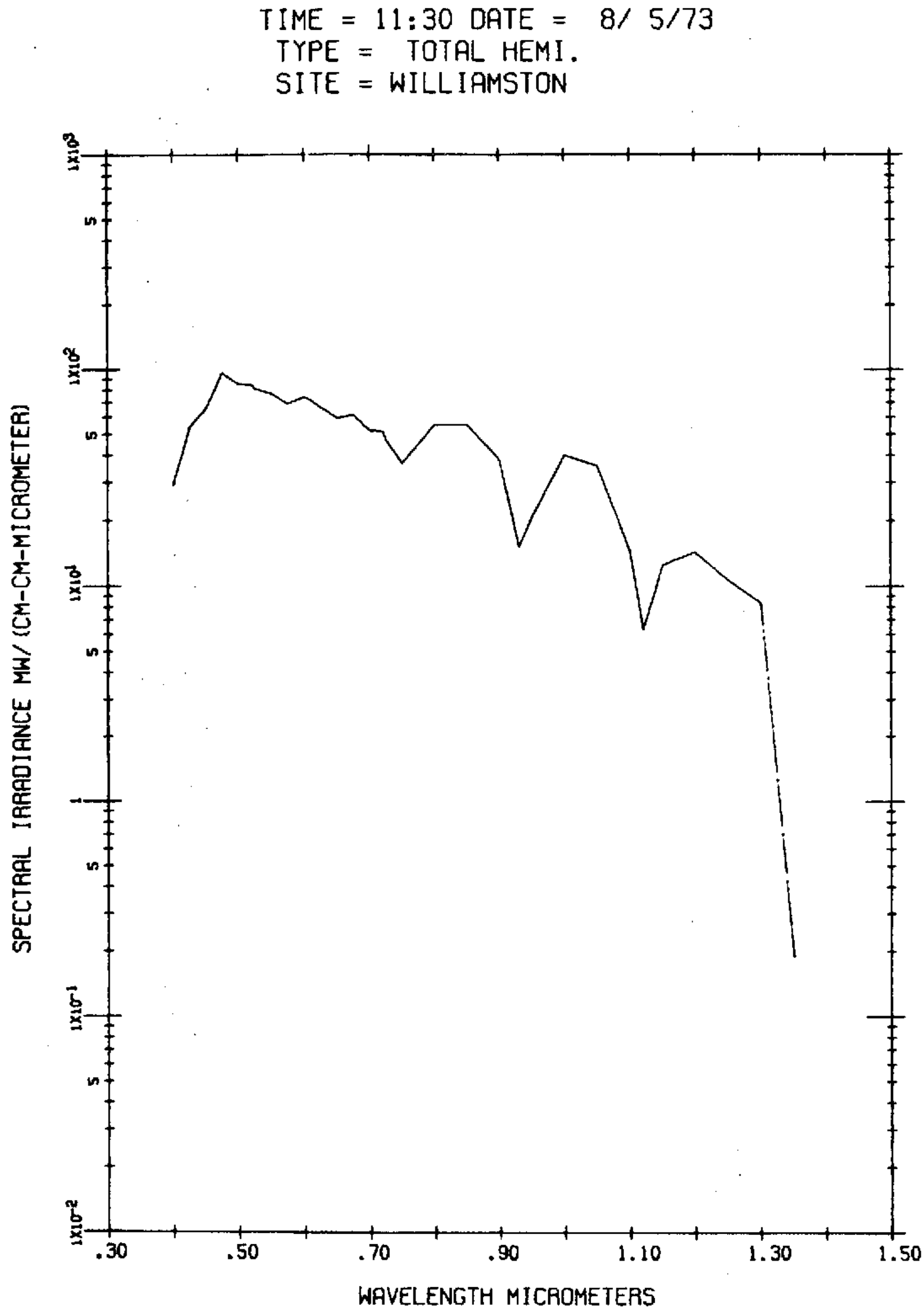


FIGURE 33. ISCO SPECTRAL IRRADIANCE DATA

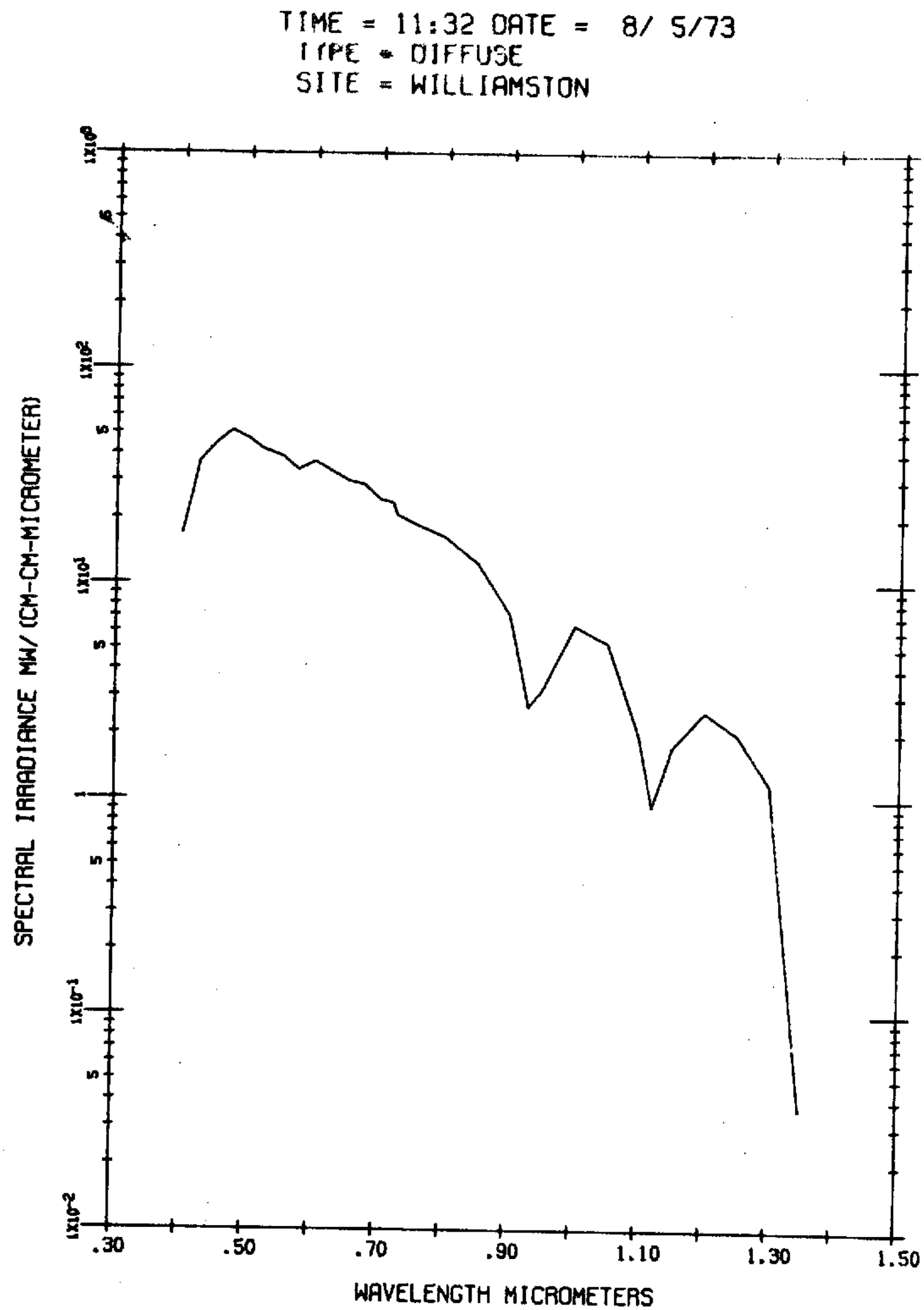


FIGURE 34. ISCO SPECTRAL IRRADIANCE DATA

TABLE 2. ISCO SPECTRAL IRRADIANCE DATA

WILLIAMSTON

DATE 8- 5-73 TIME 09*00 TITLE = TOTAL HEM

WAVELENGTH (MICROMETERS)	SPECTRAL IRRADIANCE MILLIWATTS/ (CM**2 * MICROMETER)	SPECTRAL IRRADIANCE WATTS/ (M**2 * MICROMETER)	CUMULATIVE INTEGRATED IRRADIANCE MILLIWATTS / CM ** 2	CUMULATIVE INTEGRATED IRRADIANCE WATTS / M ** 2
.400	10.90	109.05	.00	.00
.425	29.32	293.17	.50	5.03
.450	36.70	367.02	1.33	13.28
.475	40.50	405.00	2.29	22.93
.500	36.68	366.79	3.26	32.58
.520	34.60	346.01	3.97	39.71
.525	34.59	345.87	4.14	41.44
.550	35.25	352.51	5.02	50.17
.575	32.71	327.08	5.87	58.66
.600	35.84	358.44	6.72	67.23
.610	35.17	351.74	7.08	70.78
.625	34.58	345.76	7.60	76.01
.650	33.71	337.08	8.45	84.55
.675	35.78	357.83	9.32	93.23
.700	31.84	318.41	10.17	101.69
.720	31.81	318.08	10.81	108.05
.725	28.42	284.23	10.96	109.56
.750	29.82	298.15	11.68	116.84
.750	23.54	235.38	11.68	116.84
.800	19.84	198.36	12.77	127.68
.850	21.13	211.30	13.79	137.92
.900	14.80	148.05	14.65	146.91
.930	3.89	38.90	14.97	149.71
.950	5.64	56.41	15.07	150.66
1.000	15.60	156.00	15.60	155.97
1.050	13.89	138.91	16.33	163.35
1.100	4.81	48.07	16.80	168.02
1.120	1.62	16.24	16.87	168.66
1.150	3.45	34.46	16.94	169.42
1.200	7.08	70.80	17.21	172.06
1.250	6.61	66.08	17.55	175.48
1.300	4.07	40.65	17.81	178.15
1.350	.17	1.69	17.92	179.20

TABLE 3. ISCO SPECTRAL IRRADIANCE DATA

WILLIAMSTON

DATE 8- 5-73 TIME 09*04 TITLE = DIFFUSE

WAVELENGTH (MICROMETERS)	SPECTRAL IRRADIANCE MILLIWATTS/ (CM**2 * MICROMETER)	SPECTRAL IRRADIANCE WATTS/ (M**2 * MICROMETER)	CUMULATIVE INTEGRATED IRRADIANCE MILLIWATTS / CM ** 2	CUMULATIVE INTEGRATED IRRADIANCE WATTS / M ** 2
.400	11.10	111.00	.00	.00
.425	22.80	228.02	.42	4.24
.450	32.45	324.54	1.11	11.14
.475	33.90	339.00	1.94	19.44
.500	32.09	320.94	2.77	27.69
.520	29.86	298.57	3.39	33.88
.525	30.54	305.37	3.54	35.39
.550	27.96	279.59	4.27	42.70
.575	24.97	249.68	4.93	49.32
.600	27.77	277.70	5.59	55.91
.610	26.17	261.75	5.86	58.61
.625	25.27	252.75	6.25	62.47
.650	23.41	234.07	6.86	68.55
.675	23.27	232.69	7.44	74.39
.700	20.69	206.86	7.99	79.88
.720	19.78	197.78	8.39	83.93
.725	17.38	173.82	8.49	84.86
.750	16.08	160.79	8.90	89.04
.750	8.18	81.84	8.90	89.04
.800	9.61	96.10	9.35	93.49
.850	9.74	97.40	9.83	98.33
.900	4.36	43.69	10.19	101.85
.930	1.60	15.96	10.27	102.75
.950	2.95	29.55	10.32	103.20
1.000	5.39	53.92	10.53	105.29
1.050	4.16	41.60	10.77	107.68
1.100	.79	7.93	10.89	108.92
1.120	.55	5.45	10.90	109.05
1.150	1.26	12.63	10.93	109.32
1.200	1.82	18.24	11.01	110.09
1.250	1.41	14.11	11.09	110.90
1.300	.57	5.66	11.14	111.39
1.350	.03	.29	11.15	111.54

TABLE 4. ISCO SPECTRAL IRRADIANCE DATA

WILLIAMSTON

DATE 6- 5-73 TIME 09*15 TITLE = TOTAL HEM

WAVELENGTH (MICROMETERS)	SPECTRAL IRRADIANCE MILLIWATTS/ (CM**2 * MICROMETER)	SPECTRAL IRRADIANCE WATTS/ (M**2 * MICROMETER)	CUMULATIVE INTEGRATED IRRADIANCE MILLIWATTS / CM ** 2	CUMULATIVE INTEGRATED IRRADIANCE WATTS / M ** 2
.400	12.27	122.74	.00	.00
.425	28.11	281.09	.50	5.05
.450	39.32	393.24	1.35	13.48
.475	45.90	459.00	2.41	24.13
.500	42.88	428.82	3.52	35.23
.520	40.49	404.91	4.36	43.57
.525	40.34	403.38	4.56	45.59
.550	41.55	415.49	5.58	55.82
.575	37.35	373.51	6.57	65.68
.600	43.36	433.61	7.58	75.77
.610	42.32	423.19	8.01	80.06
.625	41.32	413.16	8.63	86.33
.650	40.10	400.98	9.65	96.51
.675	42.25	422.50	10.68	106.80
.700	38.19	381.95	11.69	116.86
.720	38.08	380.81	12.45	124.48
.725	34.84	348.38	12.63	126.31
.750	34.66	346.63	13.50	134.99
.750	24.76	247.59	13.50	134.99
.800	22.67	226.75	14.69	146.85
.850	23.89	238.90	15.85	158.49
.900	14.26	142.65	16.80	168.03
.930	5.53	55.33	17.10	171.00
.950	8.96	89.59	17.25	172.45
1.000	17.62	176.16	17.91	179.09
1.050	16.54	165.37	18.76	187.63
1.100	5.26	52.55	19.31	193.08
1.120	1.80	17.98	19.38	193.79
1.150	4.68	46.85	19.48	194.76
1.200	8.15	81.48	19.80	197.97
1.250	7.60	75.97	20.19	201.90
1.300	6.14	61.44	20.53	205.34
1.350	.14	1.37	20.69	206.91

TABLE 5. ISCO SPECTRAL IRRADIANCE DATA

WILLIAMSTON

DATE 8- 5-73 TIME 09*18 TITLE = DIFFUSE

WAVELENGTH (MICROMETERS)	SPECTRAL IRRADIANCE MILLIWATTS/ (CM**2 * MICROMETER)	SPECTRAL IRRADIANCE WATTS/ (M**2 * MICROMETER)	CUMULATIVE INTEGRATED IRRADIANCE MILLIWATTS / CM ** 2	CUMULATIVE INTEGRATED IRRADIANCE WATTS / M ** 2
.400	12.14	121.43	.00	.00
.425	33.89	338.92	.58	5.75
.450	36.07	360.70	1.45	14.50
.475	39.20	392.00	2.39	23.91
.500	34.61	346.11	3.31	33.13
.520	31.25	312.48	3.97	39.72
.525	31.02	310.23	4.13	41.28
.550	29.72	297.22	4.89	48.87
.575	25.78	257.76	5.58	55.81
.600	28.05	280.49	6.25	62.54
.610	27.14	271.36	6.53	65.29
.625	25.81	258.14	6.93	69.27
.650	23.93	239.28	7.55	75.48
.675	23.69	236.91	8.14	81.44
.700	20.40	204.03	8.69	86.95
.720	19.63	196.31	9.10	90.95
.725	17.23	172.33	9.19	91.87
.750	15.84	158.37	9.60	96.01
.750	8.56	85.65	9.60	96.01
.800	9.91	99.07	10.06	100.62
.850	9.69	96.89	10.55	105.52
.900	4.78	47.85	10.91	109.14
.930	1.74	17.36	11.01	110.12
.950	2.50	24.96	11.05	110.54
1.000	4.99	49.92	11.24	112.42
1.050	4.04	40.42	11.47	114.67
1.100	.82	8.16	11.59	115.89
1.120	.61	6.15	11.60	116.03
1.150	1.24	12.39	11.63	116.31
1.200	1.67	16.68	11.70	117.04
1.250	1.22	12.23	11.78	117.76
1.300	.50	5.02	11.82	118.19
1.350	.06	.59	11.83	118.33

TABLE 6. ISCO SPECTRAL IRRADIANCE DATA

WILLIAMSTON

DATE 8- 5-73 TIME 09*30 TITLE = TOTAL HEMI

WAVELENGTH (MICROMETERS)	SPECTRAL IRRADIANCE MILLIWATTS/ (CM**2 * MICROMETER)	SPECTRAL IRRADIANCE WATTS/ (M**2 * MICROMETER)	CUMULATIVE INTEGRATED IRRADIANCE MILLIWATTS / CM ** 2	CUMULATIVE INTEGRATED IRRADIANCE WATTS / M ** 2
.400	16.79	167.89	.00	.00
.425	31.60	315.98	.60	6.05
.450	35.89	358.89	1.45	14.48
.475	51.60	516.00	2.54	25.42
.500	50.97	509.73	3.82	38.24
.520	47.03	470.35	4.80	48.04
.525	46.25	462.51	5.04	50.37
.550	47.85	478.46	6.21	62.14
.575	44.22	442.16	7.36	73.64
.600	51.23	512.26	8.56	85.58
.610	49.94	499.45	9.06	90.63
.625	48.33	483.26	9.80	98.00
.650	47.14	471.40	10.99	109.94
.675	49.56	495.61	12.20	122.02
.700	45.18	451.84	13.39	133.87
.720	44.21	442.06	14.28	142.81
.725	40.88	408.81	14.49	144.93
.750	39.51	395.11	15.50	154.98
.750	38.19	381.91	15.50	154.98
.800	25.21	252.05	17.08	170.83
.850	26.69	266.87	18.38	183.81
.900	15.43	154.35	19.43	194.34
.930	5.95	59.52	19.75	197.54
.950	10.29	102.86	19.92	199.17
1.000	19.63	196.32	20.66	206.65
1.050	17.68	176.84	21.60	215.98
1.100	4.50	44.96	22.15	221.52
1.120	2.24	22.39	22.22	222.19
1.150	6.01	60.06	22.34	223.43
1.200	9.56	95.64	22.73	227.32
1.250	8.48	84.78	23.18	231.83
1.300	4.60	45.95	23.51	235.10
1.350	.10	.96	23.63	236.28

TABLE 7. ISCO SPECTRAL IRRADIANCE DATA

WILLIAMSTON

DATE 8- 5-73 TIME 09*34 TITLE = DIFFUSE

WAVELENGTH (MICROMETERS)	SPECTRAL IRRADIANCE MILLIWATTS/ (CM**2 * MICROMETER)	SPECTRAL IRRADIANCE WATTS/ (M**2 * MICROMETER)	CUMULATIVE INTEGRATED IRRADIANCE MILLIWATTS / CM ** 2	CUMULATIVE INTEGRATED IRRADIANCE WATTS / M ** 2
.400	10.56	105.62	.00	.00
.425	28.29	282.92	.49	4.86
.450	26.93	269.30	1.18	11.76
.475	41.30	413.00	2.03	20.29
.500	36.50	364.99	3.00	30.01
.520	31.66	316.57	3.68	36.83
.525	30.70	306.99	3.84	38.39
.550	29.26	292.61	4.59	45.88
.575	25.78	257.76	5.28	52.76
.600	27.56	275.62	5.94	59.43
.610	26.59	265.87	6.21	62.14
.625	25.01	250.09	6.60	66.01
.650	22.82	228.20	7.20	71.98
.675	22.85	228.47	7.77	77.69
.700	19.63	196.27	8.30	83.00
.720	18.67	186.71	8.68	86.83
.725	16.86	168.60	8.77	87.72
.750	14.46	144.63	9.16	91.64
.750	8.60	85.99	9.16	91.64
.800	9.63	96.33	9.62	96.19
.850	8.91	89.08	10.08	100.83
.900	4.84	48.45	10.43	104.27
.930	1.63	16.27	10.52	105.24
.950	1.85	18.49	10.56	105.59
1.000	4.34	43.36	10.71	107.13
1.050	3.45	34.54	10.91	109.08
1.100	1.22	12.19	11.02	110.25
1.120	.55	5.45	11.04	110.42
1.150	.93	9.32	11.06	110.65
1.200	1.36	13.56	11.12	111.22
1.250	1.09	10.88	11.18	111.83
1.300	.54	5.44	11.22	112.24
1.350	.04	.37	11.24	112.38

TABLE 8. ISCO SPECTRAL IRRADIANCE DATA

WILLIAMSTON

DATE 8- 5-73 TIME 09*45 TITLE = TOTAL HEM

WAVELENGTH (MICROMETERS)	SPECTRAL IRRADIANCE MILLIWATTS/ (CM**2 * MICROMETER)	SPECTRAL IRRADIANCE WATTS/ (M**2 * MICROMETER)	CUMULATIVE INTEGRATED IRRADIANCE MILLIWATTS / CM ** 2	CUMULATIVE INTEGRATED IRRADIANCE WATTS / M ** 2
.400	15.16	151.59	.00	.00
.425	33.79	337.94	.61	6.12
.450	40.23	402.28	1.54	15.37
.475	59.30	593.00	2.78	27.81
.500	58.17	581.65	4.25	42.50
.520	54.72	547.24	5.38	53.78
.525	54.19	541.89	5.65	56.51
.550	54.84	548.35	7.01	70.14
.575	51.89	518.88	8.35	83.48
.600	59.44	594.38	9.74	97.39
.610	57.64	576.39	10.32	103.25
.625	55.74	557.40	11.17	111.75
.650	54.25	542.46	12.55	125.50
.675	57.01	570.13	13.94	139.41
.700	52.03	520.32	15.30	153.04
.720	51.07	510.70	16.33	163.35
.725	46.62	466.25	16.58	165.79
.750	44.44	444.40	17.72	177.17
.750	37.67	376.71	17.72	177.17
.800	29.58	295.83	19.40	193.99
.850	31.11	311.09	20.92	209.16
.900	18.45	184.50	22.15	221.55
.930	6.65	66.49	22.53	225.31
.950	10.48	104.75	22.70	227.03
1.000	22.42	224.16	23.52	235.25
1.050	19.89	198.89	24.58	245.82
1.100	6.45	64.51	25.24	252.41
1.120	2.75	27.49	25.33	253.33
1.150	6.62	66.20	25.47	254.74
1.200	10.73	107.28	25.91	259.07
1.250	10.57	105.72	26.44	264.40
1.300	6.06	60.59	26.86	268.59
1.350	.10	.96	27.01	270.09

TABLE 9. ISCO SPECTRAL IRRADIANCE DATA

WILLIAMSTON

DATE 8- 5-73 TIME 09*48 TITLE = DIFFUSE

WAVELENGTH (MICROMETERS)	SPECTRAL IRRADIANCE MILLIWATTS/ (CM**2 * MICROMETER)	SPECTRAL IRRADIANCE WATTS/ (M**2 * MICROMETER)	CUMULATIVE INTEGRATED IRRADIANCE MILLIWATTS / CM ** 2	CUMULATIVE INTEGRATED IRRADIANCE WATTS / M ** 2
.400	11.88	118.83	.00	.00
.425	26.64	266.45	.48	4.82
.450	34.80	348.04	1.25	12.50
.475	37.50	375.00	2.15	21.54
.500	34.61	346.11	3.05	30.55
.520	30.51	305.11	3.71	37.06
.525	30.37	303.75	3.86	38.58
.550	28.11	281.09	4.59	45.89
.575	24.03	240.26	5.24	52.41
.600	25.96	259.61	5.87	58.66
.610	24.66	246.63	6.12	61.19
.625	23.19	231.86	6.48	64.78
.650	20.80	207.99	7.03	70.28
.675	20.18	201.76	7.54	75.40
.700	17.16	171.56	8.01	80.07
.720	16.68	166.79	8.34	83.45
.725	14.85	148.45	8.42	84.24
.750	13.01	130.09	8.77	87.72
.750	11.51	115.09	8.77	87.72
.800	8.05	80.48	9.26	92.61
.850	7.72	77.24	9.66	96.55
.900	3.78	37.80	9.94	99.43
.930	1.55	15.50	10.02	100.23
.950	1.83	18.33	10.06	100.56
1.000	3.70	36.96	10.19	101.95
1.050	2.98	29.84	10.36	103.62
1.100	.79	7.93	10.46	104.56
1.120	.43	4.29	10.47	104.68
1.150	.88	8.85	10.49	104.88
1.200	1.19	11.88	10.54	105.40
1.250	.88	8.81	10.59	105.92
1.300	.42	4.24	10.62	106.24
1.350	.05	.51	10.64	106.36

TABLE 10. ISCO SPECTRAL IRRADIANCE DATA

WILLIAMSTON

DATE 8- 5-73 TIME 10*00 TITLE = TOTAL HEM

WAVELENGTH (MICROMETERS)	SPECTRAL IRRADIANCE MILLIWATTS/ (CM**2 * MICROMETER)	SPECTRAL IRRADIANCE WATTS/ (M**2 * MICROMETER)	CUMULATIVE INTEGRATED IRRADIANCE MILLIWATTS / CM ** 2	CUMULATIVE INTEGRATED IRRADIANCE WATTS / M ** 2
.400	18.42	184.19	.00	.00
.425	39.89	398.94	.73	7.29
.450	45.65	456.52	1.80	17.98
.475	66.70	667.00	3.20	32.03
.500	66.08	660.76	4.86	48.62
.520	60.61	606.14	6.13	61.29
.525	60.67	606.69	6.43	64.32
.550	61.67	616.70	7.96	79.62
.575	57.14	571.38	9.45	94.47
.600	66.05	660.50	10.99	109.87
.610	64.51	645.09	11.64	116.39
.625	62.34	623.45	12.59	125.91
.650	60.83	608.32	14.13	141.31
.675	63.55	635.51	15.69	156.85
.700	58.24	582.45	17.21	172.08
.720	56.97	569.74	18.36	183.60
.725	52.59	525.93	18.63	186.34
.750	50.50	505.00	19.92	199.23
.750	41.13	411.35	19.92	199.23
.800	32.59	325.93	21.77	217.66
.850	33.98	339.82	23.43	234.30
.900	21.19	211.95	24.81	248.10
.930	8.74	87.42	25.26	252.59
.950	13.03	130.35	25.48	254.76
1.000	24.82	248.16	26.42	264.23
1.050	21.92	219.18	27.59	275.91
1.100	8.52	85.21	28.35	283.52
1.120	3.17	31.67	28.47	284.69
1.150	7.04	70.45	28.62	286.22
1.200	11.95	119.52	29.10	290.97
1.250	11.33	113.27	29.68	296.79
1.300	6.98	69.78	30.14	301.37
1.350	.07	.66	30.31	303.13

TABLE 11. ISCO SPECTRAL IRRADIANCE DATA

WILLIAMSTON

DATE 8- 5-73 TIME 10*04 TITLE = DIFFUSE

WAVELENGTH (MICROMETERS)	SPECTRAL IRRADIANCE MILLIWATTS/ (CM**2 * MICROMETER)	SPECTRAL IRRADIANCE WATTS/ (M**2 * MICROMETER)	CUMULATIVE INTEGRATED IRRADIANCE MILLIWATTS / CM ** 2	CUMULATIVE INTEGRATED IRRADIANCE WATTS / M ** 2
.400	14.38	143.77	.00	.00
.425	29.39	293.90	.55	5.47
.450	37.15	371.54	1.38	13.79
.475	39.60	396.00	2.34	23.38
.500	34.61	346.11	3.27	32.66
.520	30.67	306.75	3.92	39.19
.525	30.37	303.75	4.07	40.71
.550	28.19	281.86	4.80	48.03
.575	24.16	241.61	5.46	54.58
.600	25.54	255.43	6.08	60.79
.610	23.98	239.76	6.33	63.27
.625	22.98	229.83	6.68	66.79
.650	20.47	204.73	7.22	72.22
.675	19.54	195.43	7.72	77.22
.700	16.17	161.67	8.17	81.69
.720	16.01	160.15	8.49	84.90
.725	13.95	139.50	8.57	85.65
.750	12.85	128.47	8.90	89.00
.750	14.68	146.79	8.90	89.00
.800	7.57	75.70	9.46	94.57
.850	6.97	69.68	9.82	98.20
.900	4.09	40.95	10.10	100.97
.930	1.49	14.88	10.18	101.80
.950	2.10	21.01	10.22	102.16
1.000	3.49	34.88	10.36	103.56
1.050	2.81	28.08	10.51	105.13
1.100	.77	7.70	10.60	106.03
1.120	.50	4.99	10.62	106.15
1.150	.84	8.38	10.64	106.36
1.200	1.19	11.88	10.69	106.86
1.250	.89	8.90	10.74	107.38
1.300	.42	4.17	10.77	107.71
1.350	.05	.51	10.78	107.83

TABLE 12. ISCO SPECTRAL IRRADIANCE DATA

WILLIAMSTON

DATE 8- 5-73 TIME 10*18 TITLE = TOTAL HEM

WAVELENGTH (MICROMETERS)	SPECTRAL IRRADIANCE MILLIWATTS/ (CM**2 * MICROMETER)	SPECTRAL IRRADIANCE WATTS/ (M**2 * MICROMETER)	CUMULATIVE INTEGRATED IRRADIANCE MILLIWATTS / CM ** 2	CUMULATIVE INTEGRATED IRRADIANCE WATTS / M ** 2
.400	21.52	215.16	.00	.00
.425	40.14	401.38	.77	7.71
.450	50.53	505.34	1.90	19.04
.475	74.50	745.00	3.47	34.67
.500	72.37	723.69	5.30	53.03
.520	67.73	677.30	6.70	67.04
.525	67.80	677.97	7.04	70.43
.550	69.50	695.04	8.76	87.59
.575	63.80	638.00	10.43	104.25
.600	75.79	757.94	12.17	121.70
.610	72.96	729.59	12.91	129.14
.625	70.57	705.68	13.99	139.90
.650	67.29	672.86	15.71	157.14
.675	70.86	708.62	17.44	174.40
.700	65.23	652.34	19.14	191.42
.720	63.10	630.99	20.42	204.25
.725	57.96	579.64	20.73	207.28
.750	54.78	547.82	22.14	221.37
.750	42.78	427.80	22.14	221.37
.800	48.11	481.08	24.41	244.09
.850	37.46	374.60	26.55	265.48
.900	25.74	257.40	28.13	281.28
.930	10.04	100.44	28.67	286.65
.950	13.18	131.77	28.90	288.97
1.000	28.22	282.24	29.93	299.32
1.050	25.18	251.81	31.27	312.68
1.100	9.66	96.60	32.14	321.39
1.120	4.35	43.50	32.28	322.79
1.150	7.75	77.53	32.46	324.60
1.200	13.21	132.12	32.98	329.84
1.250	12.27	122.71	33.62	336.21
1.300	6.98	69.78	34.10	341.03
1.350	.46	4.63	34.29	342.89

TABLE 13. ISCO SPECTRAL IRRADIANCE DATA

WILLIAMSTON

DATE 8- 5-73 TIME 10*20 TITLE = DIFFUSE

WAVELENGTH (MICROMETERS)	SPECTRAL IRRADIANCE MILLIWATTS/ (CM**2 * MICROMETER)	SPECTRAL IRRADIANCE WATTS/ (M**2 * MICROMETER)	CUMULATIVE INTEGRATED IRRADIANCE MILLIWATTS / CM ** 2	CUMULATIVE INTEGRATED IRRADIANCE WATTS / M ** 2
.400	11.93	119.32	.00	.00
.425	27.89	278.89	.50	4.98
.450	33.36	333.58	1.26	12.63
.475	36.90	369.00	2.14	21.42
.500	33.17	331.73	3.02	30.17
.520	30.18	301.84	3.65	36.51
.525	29.89	298.89	3.80	38.01
.550	28.34	283.39	4.53	45.29
.575	24.83	248.34	5.19	51.94
.600	23.46	234.55	5.80	57.97
.610	23.43	234.27	6.03	60.32
.625	22.51	225.12	6.38	63.76
.650	20.41	204.08	6.91	69.13
.675	19.61	196.14	7.41	74.13
.700	16.66	166.62	7.87	78.67
.720	16.01	160.15	8.19	81.93
.725	14.25	142.49	8.27	82.69
.750	12.52	125.24	8.60	86.04
.750	8.76	87.55	8.60	86.04
.800	8.06	80.60	9.02	90.24
.850	7.17	71.69	9.40	94.05
.900	3.88	38.85	9.68	96.81
.930	1.52	15.19	9.76	97.62
.950	1.82	18.17	9.80	97.95
1.000	3.46	34.56	9.93	99.27
1.050	2.79	27.93	10.08	100.84
1.100	.92	9.20	10.18	101.76
1.120	.50	4.99	10.19	101.91
1.150	.91	9.09	10.21	102.12
1.200	1.16	11.64	10.26	102.63
1.250	.89	8.90	10.31	103.15
1.300	.43	4.31	10.35	103.48
1.350	.03	.29	10.36	103.59

TABLE 14. ISCO SPECTRAL IRRADIANCE DATA

WILLIAMSTON

DATE 8- 5-73 TIME 10*30 TITLE = TOTAL HEM

WAVELENGTH (MICROMETERS)	SPECTRAL IRRADIANCE MILLIWATTS/ (CM**2 * MICROMETER)	SPECTRAL IRRADIANCE WATTS/ (M**2 * MICROMETER)	CUMULATIVE INTEGRATED IRRADIANCE MILLIWATTS / CM ** 2	CUMULATIVE INTEGRATED IRRADIANCE WATTS / M ** 2
.400	19.07	190.71	.00	.00
.425	51.12	511.18	.88	8.77
.450	54.69	546.92	2.20	22.00
.475	79.70	797.00	3.88	38.80
.500	77.31	773.14	5.84	58.43
.520	71.90	719.02	7.33	73.35
.525	72.01	720.09	7.69	76.95
.550	73.65	736.51	9.52	95.15
.575	66.96	669.63	11.27	112.73
.600	75.59	755.86	13.05	130.55
.610	73.99	739.90	13.80	138.03
.625	71.78	717.81	14.90	148.96
.650	69.83	698.29	16.67	166.66
.675	74.03	740.26	18.46	184.64
.700	69.05	690.47	20.25	202.53
.720	67.08	670.84	21.61	216.14
.725	63.11	631.12	21.94	219.39
.750	57.93	579.34	23.45	234.53
.750	43.99	439.93	23.45	234.53
.800	44.92	449.16	25.68	256.75
.850	40.70	406.98	27.82	278.16
.900	27.67	276.75	29.52	295.25
.930	11.58	115.78	30.11	301.14
.950	14.84	148.36	30.38	303.78
1.000	31.10	311.04	31.53	315.26
1.050	27.39	273.86	32.99	329.69
1.100	10.45	104.53	33.93	339.35
1.120	4.77	47.68	34.09	340.87
1.150	8.04	80.36	34.28	342.79
1.200	14.18	141.84	34.83	348.34
1.250	13.30	132.96	35.52	355.21
1.300	6.95	69.50	36.03	360.28
1.350	.15	1.54	36.21	362.05

TABLE 15. ISCO SPECTRAL IRRADIANCE DATA

WILLIAMSTON

DATE 8- 5-73   TIME 10*34   TITLE = DIFFUSE

WAVELENGTH (MICROMETERS)	SPECTRAL IRRADIANCE MILLIWATTS/ (CM**2 * MICROMETER)	SPECTRAL IRRADIANCE WATTS/ (M**2 * MICROMETER)	CUMULATIVE INTEGRATED IRRADIANCE MILLIWATTS / CM ** 2	CUMULATIVE INTEGRATED IRRADIANCE WATTS / M ** 2
.400	12.86	128.61	.00	.00
.425	29.17	291.70	.53	5.25
.450	32.27	322.73	1.29	12.93
.475	38.30	383.00	2.18	21.76
.500	33.80	338.02	3.08	30.77
.520	30.02	300.21	3.72	37.15
.525	28.92	289.17	3.86	38.62
.550	27.11	271.10	4.56	45.63
.575	23.08	230.84	5.19	51.90
.600	24.29	242.90	5.78	57.82
.610	22.81	228.08	6.02	60.18
.625	21.64	216.35	6.35	63.51
.650	19.30	192.99	6.86	68.63
.675	18.21	182.08	7.33	73.32
.700	15.32	153.20	7.75	77.51
.720	14.76	147.60	8.05	80.52
.725	13.20	132.04	8.12	81.22
.750	11.80	117.97	8.43	84.34
.750	11.51	115.09	8.43	84.34
.800	8.52	85.16	8.93	89.35
.850	6.94	69.43	9.32	93.21
.900	4.45	44.55	9.61	96.06
.930	1.50	15.03	9.70	96.95
.950	1.69	16.91	9.73	97.27
1.000	3.28	32.80	9.85	98.52
1.050	2.62	26.17	10.00	99.99
1.100	.95	9.54	10.09	100.88
1.120	.50	4.99	10.10	101.03
1.150	.70	6.96	10.12	101.21
1.200	.78	7.80	10.16	101.58
1.250	.06	.63	10.18	101.79
1.300	.05	.49	10.18	101.82
1.350	.05	.51	10.18	101.84

ERIM

TABLE 16. ISCO SPECTRAL IRRADIANCE DATA

WILLIAMSTON

DATE 8- 5-73 TIME 10*45 TITLE = TOTAL HEM

WAVELENGTH (MICROMETERS)	SPECTRAL IRRADIANCE MILLIWATTS/ (CM**2 * MICROMETER)	SPECTRAL IRRADIANCE WATTS/ (M**2 * MICROMETER)	CUMULATIVE INTEGRATED IRRADIANCE MILLIWATTS / CM ** 2	CUMULATIVE INTEGRATED IRRADIANCE WATTS / M ** 2
.400	21.03	210.27	.00	.00
.425	53.07	530.70	.93	9.26
.450	57.40	574.04	2.31	23.07
.475	86.00	860.00	4.10	41.00
.500	83.61	836.07	6.22	62.20
.520	77.79	777.92	7.83	78.34
.525	77.35	773.55	8.22	82.22
.550	76.26	762.62	10.14	101.42
.575	86.21	862.11	12.17	121.73
.600	84.56	845.64	14.31	143.07
.610	79.76	797.61	15.13	151.29
.625	78.66	786.56	16.32	163.17
.650	76.09	760.88	18.25	182.52
.675	79.51	795.09	20.20	201.96
.700	74.13	741.30	22.12	221.17
.720	74.61	746.12	23.60	236.04
.725	68.71	687.07	23.96	239.63
.750	61.81	618.12	25.59	255.94
.750	54.30	542.98	25.59	255.94
.800	46.28	462.84	28.11	281.09
.850	46.24	462.42	30.42	304.22
.900	33.61	336.15	32.42	324.18
.930	12.18	121.83	33.11	331.05
.950	17.11	171.11	33.40	333.98
1.000	33.46	334.56	34.66	346.62
1.050	29.28	292.82	36.23	362.31
1.100	11.35	113.50	37.25	372.47
1.120	4.70	46.98	37.41	374.07
1.150	10.23	102.31	37.63	376.31
1.200	15.98	159.84	38.29	382.86
1.250	14.70	146.99	39.05	390.54
1.300	12.34	123.44	39.73	397.30
1.350	.01	.07	40.04	400.38

TABLE 17. ISCO SPECTRAL IRRADIANCE DATA

WILLIAMSTON

DATE 8- 5-73   TIME 11*00   TITLE = TOTAL HEM

WAVELENGTH (MICROMETERS)	SPECTRAL IRRADIANCE MILLIWATTS/ (CM**2 * MICROMETER)	SPECTRAL IRRADIANCE WATTS/ (M**2 * MICROMETER)	CUMULATIVE INTEGRATED IRRADIANCE MILLIWATTS / CM ** 2	CUMULATIVE INTEGRATED IRRADIANCE WATTS / M ** 2
.400	24.12	241.24	.00	.00
.425	55.51	555.10	1.00	9.95
.450	60.66	606.58	2.45	24.48
.475	90.30	903.00	4.33	43.35
.500	88.91	889.11	6.57	65.75
.520	81.06	810.64	8.27	82.74
.525	97.20	972.00	8.72	87.20
.550	92.39	923.90	11.09	110.90
.575	80.96	809.62	13.26	132.57
.600	83.73	837.29	15.32	153.15
.610	82.65	826.46	16.15	161.47
.625	81.08	810.82	17.38	173.75
.650	78.24	782.40	19.37	193.67
.675	82.46	824.62	21.38	213.76
.700	79.42	794.25	23.40	233.99
.720	77.71	777.11	24.97	249.71
.725	72.73	727.35	25.35	253.47
.750	65.21	652.06	27.07	270.71
.750	12.82	128.17	27.07	270.71
.800	48.11	481.08	28.59	285.94
.850	43.22	432.18	30.88	308.77
.900	30.51	305.10	32.72	327.20
.930	12.93	129.27	33.37	333.72
.950	19.10	191.02	33.69	336.92
1.000	35.28	352.80	35.05	350.52
1.050	31.18	311.79	36.71	367.13
1.100	10.38	103.84	37.75	377.52
1.120	5.53	55.33	37.91	379.12
1.150	12.21	122.13	38.18	381.78
1.200	17.14	171.36	38.91	389.11
1.250	15.78	157.77	39.73	397.34
1.300	6.99	69.92	40.30	403.04
1.350	.04	.37	40.48	404.79

TABLE 18. ISCO SPECTRAL IRRADIANCE DATA

WILLIAMSTON

DATE 8- 5-73 TIME 11*06 TITLE = DIFFUSE

WAVELENGTH (MICROMETERS)	SPECTRAL IRRADIANCE MILLIWATTS/ (CM**2 * MICROMETER)	SPECTRAL IRRADIANCE WATTS/ (M**2 * MICROMETER)	CUMULATIVE INTEGRATED IRRADIANCE MILLIWATTS / CM ** 2	CUMULATIVE INTEGRATED IRRADIANCE WATTS / M ** 2
.400	14.43	144.25	.00	.00
.425	30.56	305.61	.56	5.62
.450	41.04	410.42	1.46	14.57
.475	43.30	433.00	2.51	25.12
.500	37.49	374.88	3.52	35.21
.520	32.88	328.84	4.23	42.25
.525	31.83	318.33	4.39	43.87
.550	29.11	291.07	5.15	51.49
.575	25.51	255.07	5.83	58.31
.600	26.73	267.26	6.48	64.84
.610	25.42	254.19	6.75	67.45
.625	24.06	240.62	7.12	71.16
.650	21.19	211.90	7.68	76.82
.675	20.60	205.98	8.20	82.04
.700	17.44	174.38	8.68	86.80
.720	16.46	164.57	9.02	90.19
.725	14.92	149.20	9.10	90.97
.750	13.09	130.90	9.45	94.47
.750	10.89	108.86	9.45	94.47
.800	8.29	82.88	9.93	99.26
.850	7.50	74.97	10.32	103.21
.900	4.15	41.55	10.61	106.12
.930	1.70	17.05	10.70	107.00
.950	2.13	21.33	10.74	107.39
1.000	3.60	36.00	10.88	108.82
1.050	2.79	27.93	11.04	110.42
1.100	.93	9.31	11.13	111.35
1.120	.52	5.22	11.15	111.49
1.150	.98	9.79	11.17	111.72
1.200	1.25	12.48	11.23	112.28
1.250	.93	9.26	11.28	112.82
1.300	.46	4.60	11.32	113.17
1.350	.01	.07	11.33	113.28

TABLE 19. ISCO SPECTRAL IRRADIANCE DATA

WILLIAMSTON

DATE 8- 5-73 TIME 11*15 TITLE = TOTAL HEM

WAVELENGTH (MICROMETERS)	SPECTRAL IRRADIANCE MILLIWATTS/ (CM**2 * MICROMETER)	SPECTRAL IRRADIANCE WATTS/ (M**2 * MICROMETER)	CUMULATIVE INTEGRATED IRRADIANCE MILLIWATTS / CM ** 2	CUMULATIVE INTEGRATED IRRADIANCE WATTS / M ** 2
.400	22.66	226.57	.00	.00
.425	61.12	611.22	1.05	10.47
.450	69.16	691.56	2.68	26.76
.475	99.30	993.00	4.78	47.81
.500	102.76	1027.56	7.31	73.07
.520	93.50	934.97	9.27	92.70
.525	92.58	925.83	9.73	97.35
.550	89.16	891.65	12.01	120.07
.575	81.77	817.69	14.14	141.43
.600	96.05	960.48	16.37	163.66
.610	94.19	941.88	17.32	173.17
.625	89.98	899.79	18.70	186.99
.650	87.24	872.38	20.91	209.14
.675	92.37	923.74	23.16	231.59
.700	86.84	868.38	25.40	253.99
.720	83.69	836.89	27.10	271.04
.725	78.11	781.06	27.51	275.09
.750	71.99	719.93	29.39	293.85
.750	59.49	594.94	29.39	293.85
.800	51.19	511.86	32.15	321.52
.850	55.69	556.92	34.82	348.24
.900	35.95	359.55	37.12	371.15
.930	14.65	146.47	37.87	378.74
.950	21.61	216.14	38.24	382.37
1.000	39.02	390.24	39.75	397.53
1.050	34.71	347.07	41.60	415.96
1.100	10.80	107.98	42.73	427.34
1.120	6.09	60.90	42.90	429.03
1.150	12.78	127.79	43.19	431.86
1.200	19.51	195.12	43.99	439.93
1.250	17.21	172.07	44.91	449.11
1.300	14.36	143.59	45.70	457.00
1.350	.17	1.69	46.06	460.63

TABLE 20. ISCO SPECTRAL IRRADIANCE DATA

WILLIAMSTON

DATE 8- 5-73 TIME 11*15 TITLE = DIFFUSE

WAVELENGTH (MICROMETERS)	SPECTRAL IRRADIANCE MILLIWATTS/ (CM**2 * MICROMETER)	SPECTRAL IRRADIANCE WATTS/ (M**2 * MICROMETER)	CUMULATIVE INTEGRATED IRRADIANCE MILLIWATTS / CM ** 2	CUMULATIVE INTEGRATED IRRADIANCE WATTS / M ** 2
.400	16.77	167.73	.00	.00
.425	33.53	335.26	.63	6.29
.450	38.60	386.01	1.53	15.30
.475	48.00	480.00	2.61	26.13
.500	41.26	412.64	3.73	37.29
.520	36.73	367.28	4.51	45.09
.525	36.13	361.26	4.69	46.91
.550	33.18	331.78	5.56	55.57
.575	28.33	283.33	6.33	63.26
.600	30.55	305.54	7.06	70.62
.610	29.33	293.35	7.36	73.61
.625	27.30	272.97	7.79	77.86
.650	24.45	244.50	8.43	84.33
.675	23.76	237.61	9.04	90.36
.700	19.91	199.09	9.58	95.82
.720	19.19	191.88	9.97	99.72
.725	17.16	171.58	10.06	100.63
.750	15.43	154.33	10.47	104.71
.750	13.74	137.43	10.47	104.71
.800	11.14	111.38	11.09	110.93
.850	9.31	93.11	11.60	116.04
.900	5.22	52.20	11.97	119.67
.930	1.94	19.37	12.07	120.75
.950	2.48	24.81	12.12	121.19
1.000	4.43	44.32	12.29	122.92
1.050	3.70	37.04	12.50	124.95
1.100	1.18	11.84	12.62	126.17
1.120	.65	6.50	12.64	126.36
1.150	1.22	12.15	12.66	126.64
1.200	1.54	15.36	12.73	127.32
1.250	1.16	11.60	12.80	128.00
1.300	.60	6.01	12.84	128.44
1.350	.04	.37	12.86	128.60

TABLE 21. ISCO SPECTRAL IRRADIANCE DATA

WILLIAMSTON

DATE 8- 5-73 TIME 11*23 TITLE = TOTAL HEM

WAVELENGTH (MICROMETERS)	SPECTRAL IRRADIANCE MILLIWATTS/ (CM**2 * MICROMETER)	SPECTRAL IRRADIANCE WATTS/ (M**2 * MICROMETER)	CUMULATIVE INTEGRATED IRRADIANCE MILLIWATTS / CM ** 2	CUMULATIVE INTEGRATED IRRADIANCE WATTS / M ** 2
.400	26.41	264.06	.00	.00
.425	60.39	603.90	1.08	10.85
.450	67.44	674.38	2.68	26.83
.475	59.30	593.00	4.77	47.67
.500	93.05	930.46	7.17	71.71
.520	85.64	856.45	8.96	89.58
.525	85.29	852.93	9.39	93.86
.550	87.32	873.22	11.54	115.43
.575	81.37	813.66	13.65	136.52
.600	94.17	941.69	15.85	158.46
.610	93.16	931.57	16.78	167.83
.625	90.18	901.81	18.16	181.58
.650	87.43	874.33	20.38	203.78
.675	92.16	921.63	22.62	226.23
.700	85.57	855.67	24.84	248.45
.720	84.57	845.75	26.55	265.46
.725	78.33	783.30	26.95	269.53
.750	71.99	719.93	28.83	288.32
.750	64.34	643.44	28.83	288.32
.800	55.75	557.46	31.83	318.34
.850	54.05	540.54	34.58	345.79
.900	39.55	395.55	36.92	369.20
.930	14.55	145.54	37.73	377.31
.950	20.00	200.03	38.08	380.77
1.000	39.50	395.04	39.56	395.65
1.050	35.41	354.12	41.44	414.37
1.100	16.32	163.18	42.73	427.31
1.120	6.09	60.90	42.95	429.55
1.150	11.29	112.93	43.22	432.16
1.200	18.47	184.68	43.96	439.60
1.250	17.45	174.50	44.86	448.58
1.300	13.77	137.65	45.64	456.38
1.350	.72	7.20	46.00	460.00

TABLE 22. ISCO SPECTRAL IRRADIANCE DATA

WILLIAMSTON

DATE 8- 5-73 TIME 11*30 TITLE = TOTAL HEM

WAVELENGTH (MICROMETERS)	SPECTRAL IRRADIANCE MILLIWATTS/ (CM**2 * MICROMETER)	SPECTRAL IRRADIANCE WATTS/ (M**2 * MICROMETER)	CUMULATIVE INTEGRATED IRRADIANCE MILLIWATTS / CM ** 2	CUMULATIVE INTEGRATED IRRADIANCE WATTS / M ** 2
.400	29.18	291.77	.00	.00
.425	53.56	535.58	1.03	10.34
.450	65.36	653.59	2.52	25.21
.475	96.30	963.00	4.54	45.41
.500	85.49	854.95	6.81	68.14
.520	85.15	851.54	8.52	85.20
.525	81.40	814.05	8.94	89.37
.550	77.18	771.84	10.92	109.19
.575	69.25	692.52	12.75	127.50
.600	74.54	745.42	14.55	145.47
.610	71.93	719.29	15.28	152.79
.625	66.52	665.24	16.32	163.18
.650	59.27	592.67	17.89	178.90
.675	61.37	613.72	19.40	193.98
.700	51.89	518.91	20.81	208.14
.720	51.59	515.86	21.85	218.49
.725	46.77	467.74	22.09	220.95
.750	36.60	366.02	23.14	231.37
.750	61.40	613.99	23.14	231.37
.800	55.18	551.76	26.05	260.51
.850	55.31	553.14	28.81	288.13
.900	38.11	381.15	31.15	311.49
.930	15.07	150.66	31.95	319.47
.950	20.81	208.09	32.31	323.06
1.000	40.08	400.80	33.83	338.28
1.050	35.85	358.53	35.73	357.26
1.100	14.46	144.55	36.98	369.84
1.120	6.30	62.99	37.19	371.91
1.150	12.46	124.61	37.47	374.73
1.200	14.33	143.28	38.14	381.42
1.250	10.71	107.07	38.77	387.68
1.300	8.42	84.20	39.25	392.47
1.350	.19	1.91	39.46	394.62

TABLE 23. ISCO SPECTRAL IRRADIANCE DATA

WILLIAMSTON

DATE 8- 5-73 TIME 11*32 TITLE = DIFFUSE

WAVELENGTH (MICROMETERS)	SPECTRAL IRRADIANCE MILLIWATTS/ (CM**2 * MICROMETER)	SPECTRAL IRRADIANCE WATTS/ (M**2 * MICROMETER)	CUMULATIVE INTEGRATED IRRADIANCE MILLIWATTS / CM ** 2	CUMULATIVE INTEGRATED IRRADIANCE WATTS / M ** 2
.400	17.02	170.17	.00	.00
.425	36.42	364.17	.67	6.68
.450	44.21	442.06	1.68	16.76
.475	51.30	513.00	2.87	28.70
.500	47.02	470.18	4.10	40.99
.520	42.29	422.91	4.99	49.92
.525	41.55	415.53	5.20	52.01
.550	39.01	390.14	6.21	62.08
.575	33.72	337.17	7.12	71.17
.600	36.82	368.18	8.00	79.99
.610	35.52	355.18	8.36	83.61
.625	33.23	332.28	8.88	88.76
.650	30.19	301.88	9.67	96.69
.675	28.96	289.64	10.41	104.08
.700	24.64	246.39	11.08	110.79
.720	23.84	238.37	11.56	115.63
.725	20.96	209.63	11.68	116.75
.750	19.23	192.30	12.18	121.78
.750	17.74	177.44	12.18	121.78
.800	16.52	165.19	13.03	130.34
.850	12.49	124.87	13.76	137.59
.900	7.24	72.45	14.25	142.53
.930	2.68	26.81	14.40	144.02
.950	3.19	31.92	14.46	144.60
1.000	6.45	64.48	14.70	147.01
1.050	5.34	53.36	15.00	149.96
1.100	1.94	19.43	15.18	151.78
1.120	.93	9.28	15.21	152.07
1.150	1.73	17.35	15.25	152.47
1.200	2.56	25.56	15.35	153.54
1.250	2.00	20.05	15.47	154.68
1.300	1.18	11.81	15.55	155.47
1.350	.04	.37	15.58	155.78

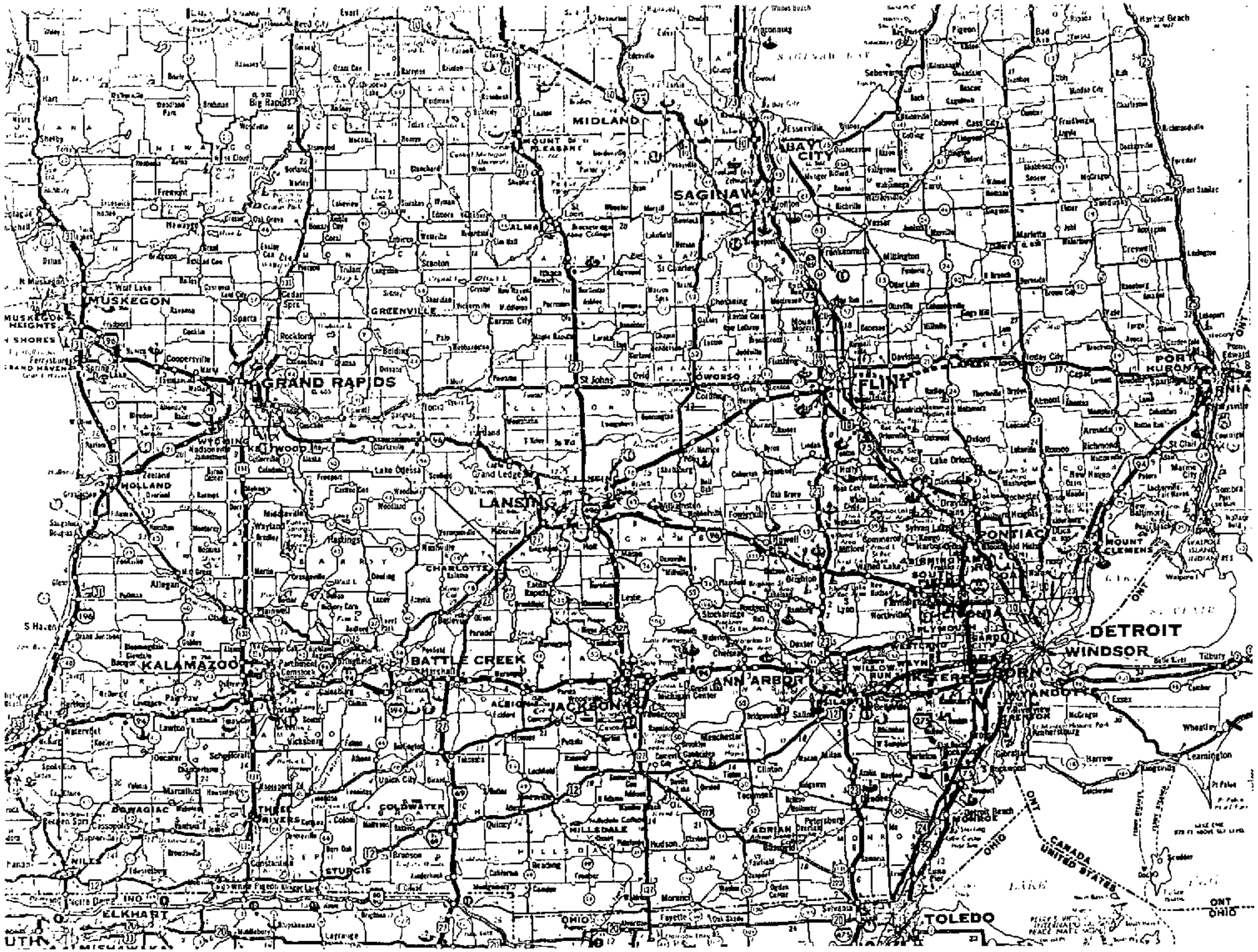


FIGURE 35. EXERPT OF ROAD MAP OF SOUTHERN LOWER MICHIGAN

Table 24 WEATHER DATA

LANSING

Time	Sky & Ceiling	Vis	Pres	Temp	Dew	Wind Dir	Wind Speed
7:00am	10,000 ft. Scattered	7 mi.	1020.2	62^o	58	190^o	7 kts.
8:00am	Clear	7 mi.	1020.4	65^o	58	190^o	7 kts.
9:00am	Clear	11 mi.	1020.3	70^o	60	200^o	11 kts.
10:00am	Clear	11 mi.	1020.3	74^o	64	210^o	10 kts.
11:00am	Clear	11 mi.	1020.2	79^o	65	220^o	8 kts.
12:00N	3,500 ft. Scattered	11 mi.	1019.5	82^o	66	190^o	10 kts.
1:00pm	3,500 ft. Scattered	8 mi.	1019.5	84^o	68	220^o	12 kts.
2:00pm	-----NO READING-----						
3:00pm	30,000 ft. Scattered	8 mi.	1018.1	86^o	68	260^o	8 kts.

JACKSON

Time	Sky & Ceiling	Vis	Pres	Temp	Dew	Wind Dir	Wind Speed
7:00am	25,000 ft. Scattered, Thin	14 mi. plus	1020.5	59^o	56	-----CALM-----	
8:00am	9,000 ft. Scattered 25,000 ft. Scattered, Thin	14 mi. plus	1020.5	65^o	60	180^o	5 kts.
9:00am	25,000 ft. Scattered	7 mi. plus	1020.4	71^o	61	210^o	8 kts.
10:00am	10,000 ft. Scattered	7 mi. plus	1020.9	75^o	63	210^o	9 kts.
11:00am	10,000 ft. Scattered	7 mi. plus	1020.9	78^o	64	190^o	10 kts.
12:00N	4,000 ft. Estimated broken	5 mi. Haze	1020.1	80^o	66	210^o	10 kts.
1:00pm	3,200 ft. Measured broken	6 mi. Haze	1019.9	83^o	68	210^o	12 kts.
2:00pm	3,500 ft. Scattered	5 mi. Haze	1019.6	84^o	69	180^o	12 kts.
3:00pm	3,500 ft. Scattered	5 mi. Haze	1019.0	85^o	70	200^o	10 kts.

Table 24 Con't.

BATTLE CREEK

Time	Sky & Ceiling	Vis	Pres	Temp	Dew	Wind Dir	Wind Speed
7:00am	15,000 ft. Estimated, Broken	10 mi.		63°	57	190°	7 kts.
8:00am	3,500 ft. Scattered 15,000 ft. Estimated, Broken	10 mi.		65°	57	200°	10 kts.
9:00am	3,500 ft. Estimated, Overcast	10 mi.		66°	59	220°	12 kts.
10:00am	Clear	5 mi. Haze		76°	64	210°	8 kts.
11:00am	4,000 ft. Broken	5 mi. Haze		77°	65	210°	10 kts.
12:00N	4,000 ft. Estimated Broken	5 mi. Haze		80°	69	260°	8 kts.
1:00pm	4,000 ft. Estimated Broken	5 mi. Haze		80°	69	240°	11 kts.
2:00pm	4,000 ft. Estimated Broken	5 mi. Haze		82°	70	220°	10 kts.
3:00pm	4,000 ft. Estimated Broken	5 mi. Haze		84°	69	230°	10 kts.

GRAND RAPIDS

Time	Sky & Ceiling	Vis	Pres	Temp	Dew	Wind Dir	Wind Speed
7:00am	Clear	10 mi.	1019.9	62°	57	190°	5 kts.
8:00am	3,500 ft. Scattered	8 mi.	1020.2	65°	59	180°	4 kts.
9:00am	Clear	9 mi.	1019.8	70°	62	200°	7 kts.
10:00am	Clear	9 mi.	1019.8	75°	65	210°	8 kts.
11:00am	Clear	9 mi.	1019.8	79°	67	220°	11 kts.
12:00N	Clear	9 mi.	1019.5	82°	68	230°	10 kts.
1:00pm	4,000 ft. Scattered	10 mi.	1018.9	85°	66	220°	10 kts.
2:00pm	4,000 ft. Scattered	12 mi.	1018.5	88°	65	230°	13 kts.
3:00pm	4,000 ft. Scattered 25,000 ft. Scattered, Thin	13 mi.	1018.2	89°	64	250°	12 kts.

Table 24 Con't.

BAY CITY

Time	Sky & Ceiling	Vis	Pres	Temp	Dew	Wind Dir	Wind Speed
7:00am	25,000 ft. Thin	7 mi.	1020.1	62°	59	180° Est.	6 kts.
8:00am	25,000 ft. Thin	5 mi. Haze	1020.1	64°	60	190° Est.	10 kts.
9:00am	Clear	6 mi. Haze	1019.7	69°	61	190°	13 kts.
10:00am	25,000 ft. Thin, Scattered	6 mi. Haze	1019.7	72°	64	210°	9 kts.
11:00am	25,000 ft. Thin, Scattered	4 mi. Haze	1019.3	76°	68	190°	13 kts.
12:00N	25,000 ft. Thin, Scattered	5 mi. Haze	1019.0	79°	69	210°	12 kts.
1:00pm	4,000 ft. Scattered	5 mi. Haze	1018.7	82°	72	200°	10 kts.
2:00pm	3,500 ft. Estimated Overcast	5 mi. Haze	1018.0	83°	72	210°	12 kts.
3:00pm	3,500 ft. Overcast	6 mi.	1017.6	85°	72	190°	15 kts.

FLINT

Time	Sky & Ceiling	Vis	Pres	Temp	Dew	Wind Dir	Wind Speed
7:00am	25,000 ft. Thin, Scattered	8 mi.	1020.3	60°	57	200°	5 kts.
8:00am	Clear	8 mi.	1020.4	64°	59	200°	5 kts.
9:00am	3,000 ft.	10 mi.	1020.1	69°	61	210°	8 kts.
10:00am	Clear	8 mi.	1020.1	73°	60	210°	10 kts.
11:00am	Clear	8 mi.	1019.7	76°	63	230°	10 kts.
12:00N	Clear	8 mi.	1019.4	79°	65	220°	11 kts.
1:00pm	3,000 ft. Scattered	7 mi.	1019.0	79°	66°	230°	11 kts.
2:00pm	3,000 ft. Estimated, Overcast	7 mi.	1018.8	81°	67	230°	7 kts.
3:00pm	4,000 ft. Estimated, Overcast	7 mi.	1018.0	83°	67	200°	12 kts.

Table 24 Con't.

DETROIT

Time	Sky & Ceiling	Vis	Pres	Temp	Dew	Wind Dir	Wind Speed
7:00am	Clear	4 mi. Haze, Smoke		64°	58	----CLEAR----	
8:00am	Clear	4 mi. Haze, Smoke		68°	60	230°	3 kts.
9:00am	Clear	5 mi. Haze, Smoke		72°	60	230°	4 kts.
10:00am	Clear	6 mi. Haze, Smoke		76°	60	240°	11 kts.
11:00am	Clear	8 mi.		78°	59	240°	11 kts.
12:00N	4,000 ft. Clear, Scattered	8 mi.		79°	61	220°	16 kts.
1:00pm	4,000 ft. Estimated, Broken	7 mi.		80°	62	240°	14 kts.
2:00pm	4,000 ft. Estimated, Broken	7 mi.		80°	62	250°	10 kts.
3:00pm	5,500 ft. Estimated, Broken Haze	6 mi.		84°	64	230°	10 kts.

DETROIT METRO

Time	Sky & Ceiling	Vis	Pres	Temp	Dew	Wind Dir	Wind Speed
7:00am	Clear	6 mi. Haze	1020.8	59°	58	210°	3 kts.
8:00am	Clear	6 mi. Haze	1021.1	63°	60	260°	4 kts.
9:00am	Clear	8 mi.	1020.9	70°	64	230°	5 kts.
10:00am	Clear	15 mi.	1021.3	75°	64	250°	10 kts.
11:00am	Clear	15 mi.	1021.0	78°	59	240°	11 kts.
12:00N	3,500 ft. Estimated, Broken	15 mi.	1020.6	80°	64	230°	10 kts.
1:00pm	3,500 ft. Scattered	12 mi.	1020.1	81°	65	210°	13 kts.
2:00pm	3,500 ft. Scattered	10 mi.	1019.6	82°	66	240°	10 kts.
3:00pm	4,000 ft. Estimated Broken	6 mi. Haze, Smoke		81°		5°	8 kts.

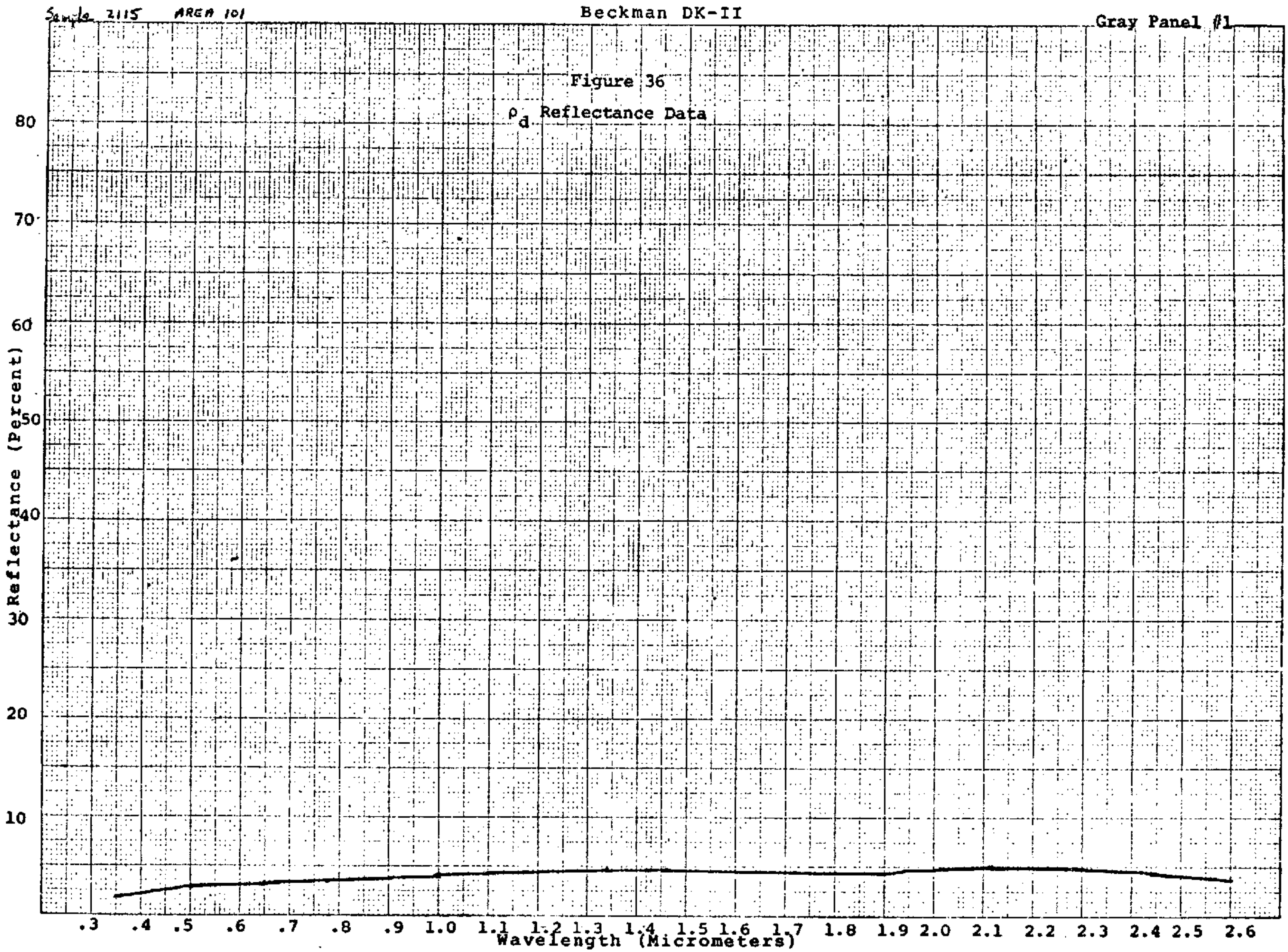
Table 24 Con't.

YPSILANTI

Time	Sky & Ceiling	Vis	Pres	Temp	Dew	Wind Dir	Wind Speed
7:00am	Clear	10 mi.		60°	57	240°	4 kts.
8:00am	Clear	10 mi.		65°	60	230°	3 kts.
9:00am	Clear	7 mi.		71°	62	220°	5 kts.
10:00am	Clear	10 mi.		75°	61	230°	10 kts.
11:00am	Clear	10 mi.		77°	61	230°	10 kts.
12:00N	Clear	10 mi.		79°	62	230°	10 kts.
1:00pm	4,000 ft. Scattered	10 mi.		80°	63	220°	10 kts.
2:00pm	4,000 ft. Scattered	10 mi.		81°	64	210°	13 kts.
3:00pm	3,500 ft.	8 mi.	1019.3	81°	66	240°	13 kts.

PONTIAC

Time	Sky & Ceiling	Vis	Pres	Temp	Dew	Wind Dir	Wind Speed
7:00am	Clear	7 mi.		64°	57	----CALM----	
8:00am	Clear	10 mi.		67°	58	----CALM----	
9:00am	12,000 ft. Scattered	7 mi.		72°	60	220°	5 kts.
10:00am	12,000 ft. Scattered	7 mi.		76°	60	240°	10 kts.
11:00am	12,000 ft. Scattered	7 mi.		80°	60	240°	8 kts.
12:00N	4,500 ft. Scattered	7 mi.		80°	60	240°	12 kts.
1:00pm	4,500 ft. Estimated, Broken	7 mi.		81°	61	240°	12 kts.
2:00pm	4,500 ft. Estimated, Broken	7 mi.		81°	63	240°	10 kts.
3:00pm	4,000 ft. Estimated, Broken	7 mi.		83°	64	210°	10 kts.


Sample 2115 AREA 101
Beckman DK-II
Gray Panel #1
Figure 36
ρ_d Reflectance Data
Reflectance (Percent)
80
70
60
50
40
30
20
10
.3 .4 .5 .6 .7 .8 .9 1.0 1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8 1.9 2.0 2.1 2.2 2.3 2.4 2.5 2.6
Wavelength (Micrometers)

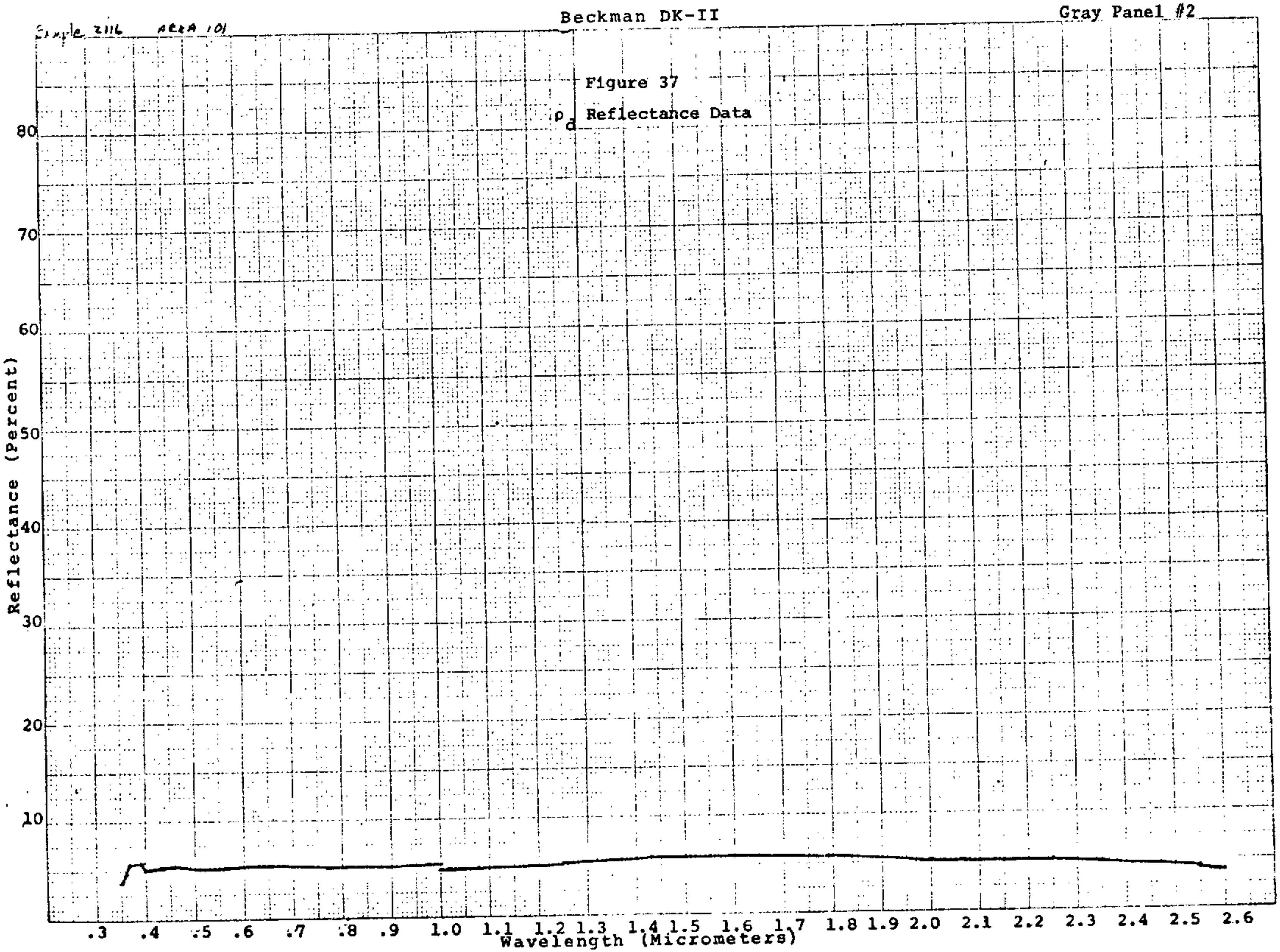
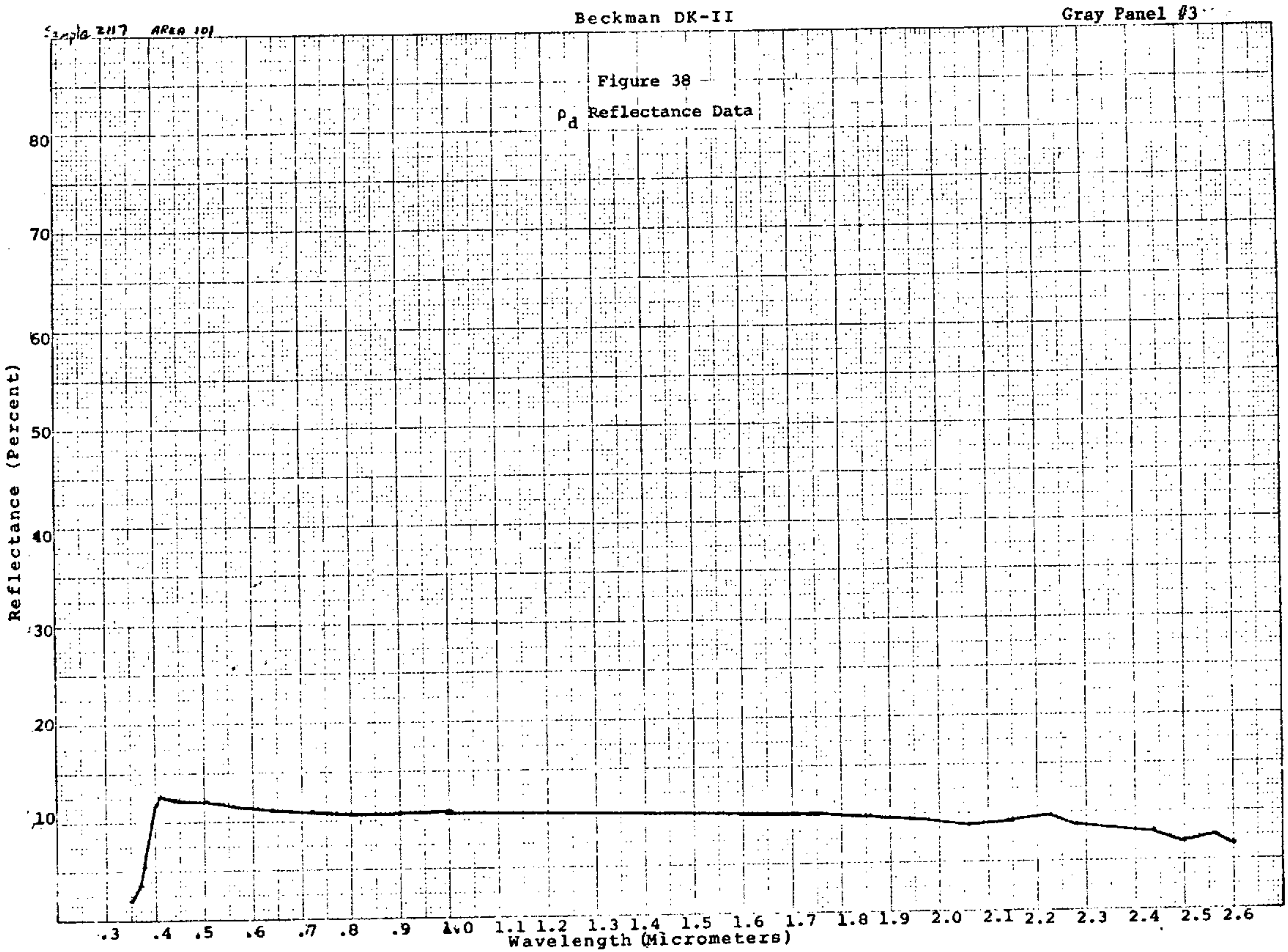
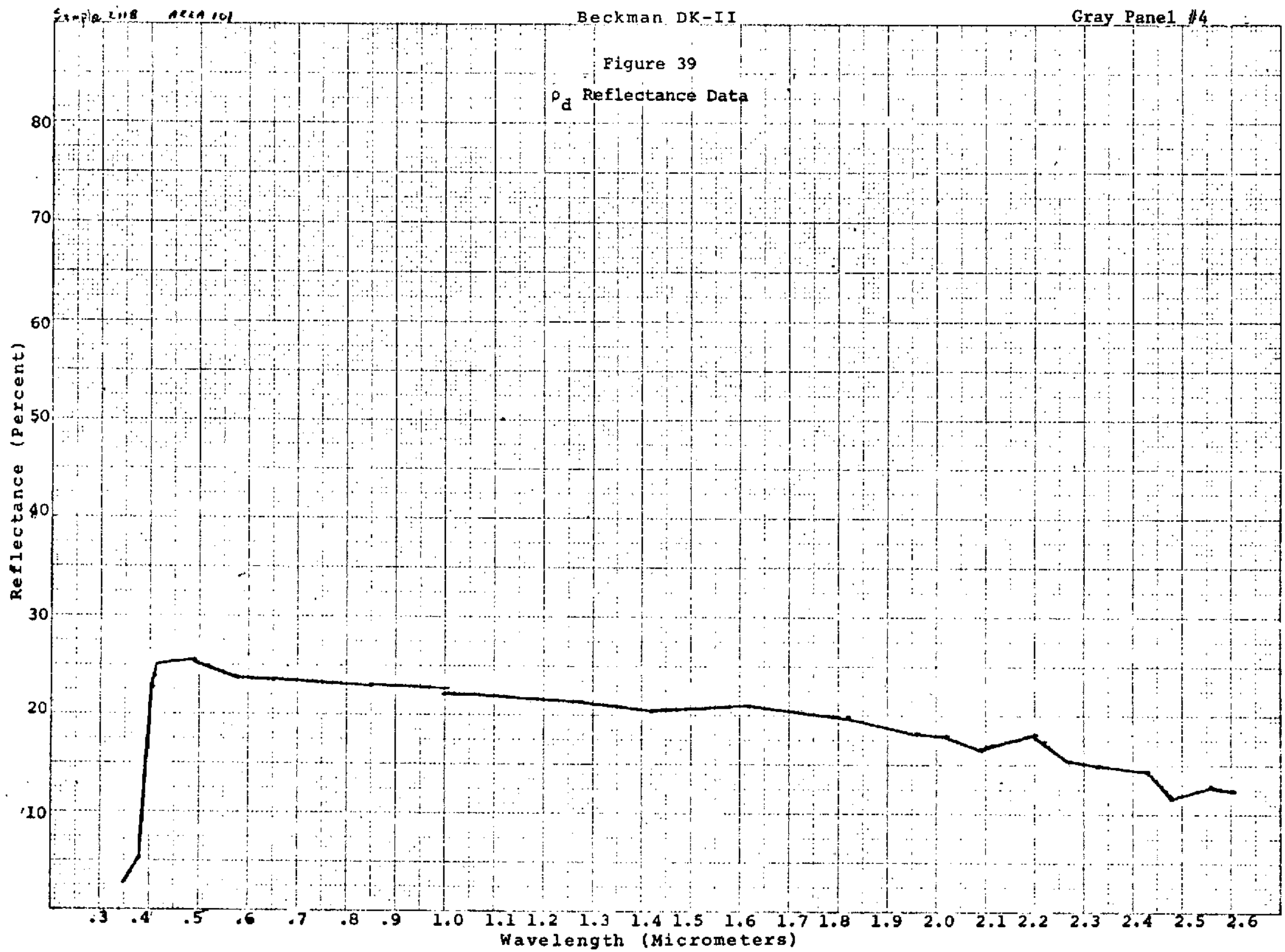


Figure 37

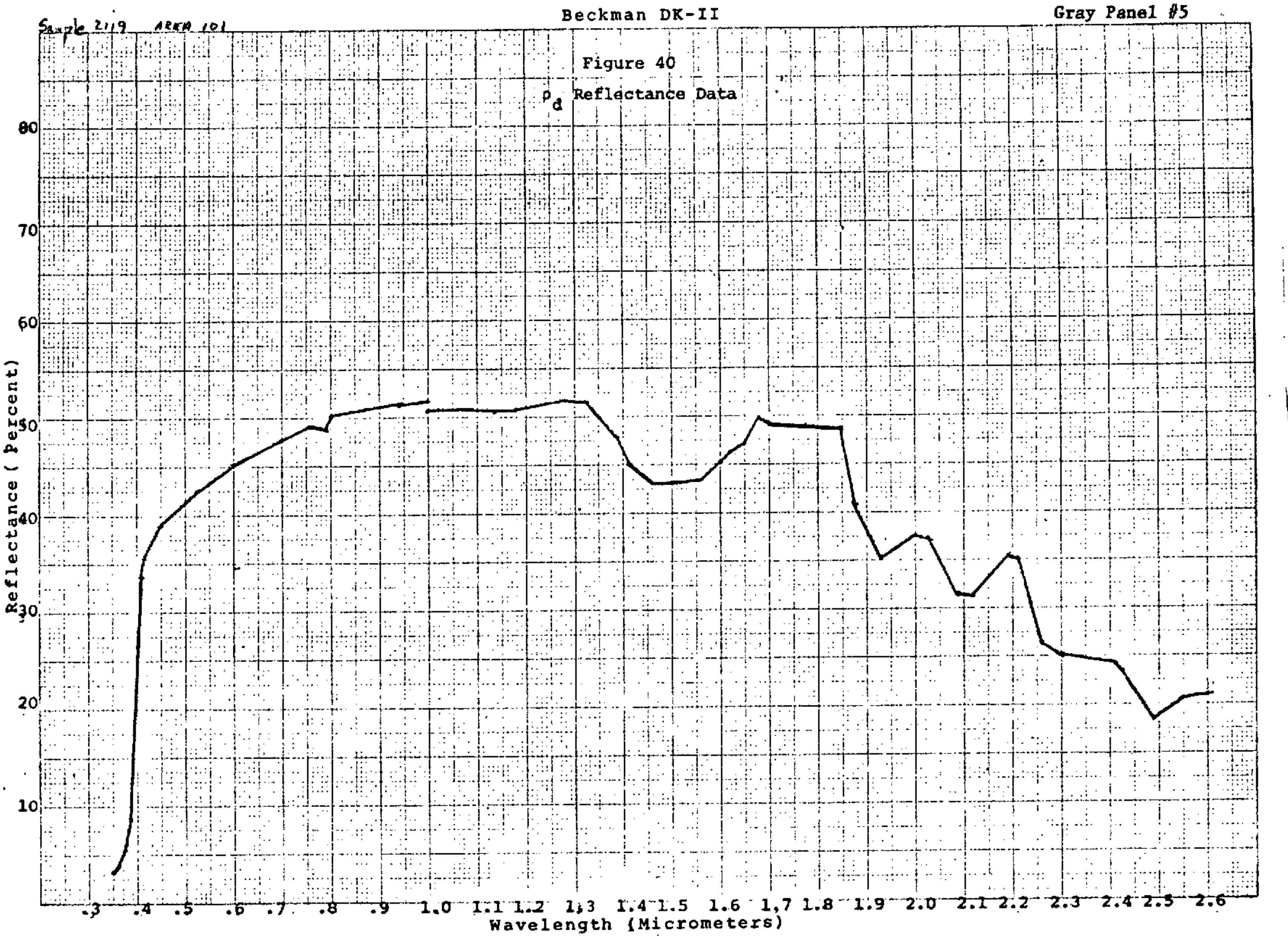
ρ_d Reflectance Data



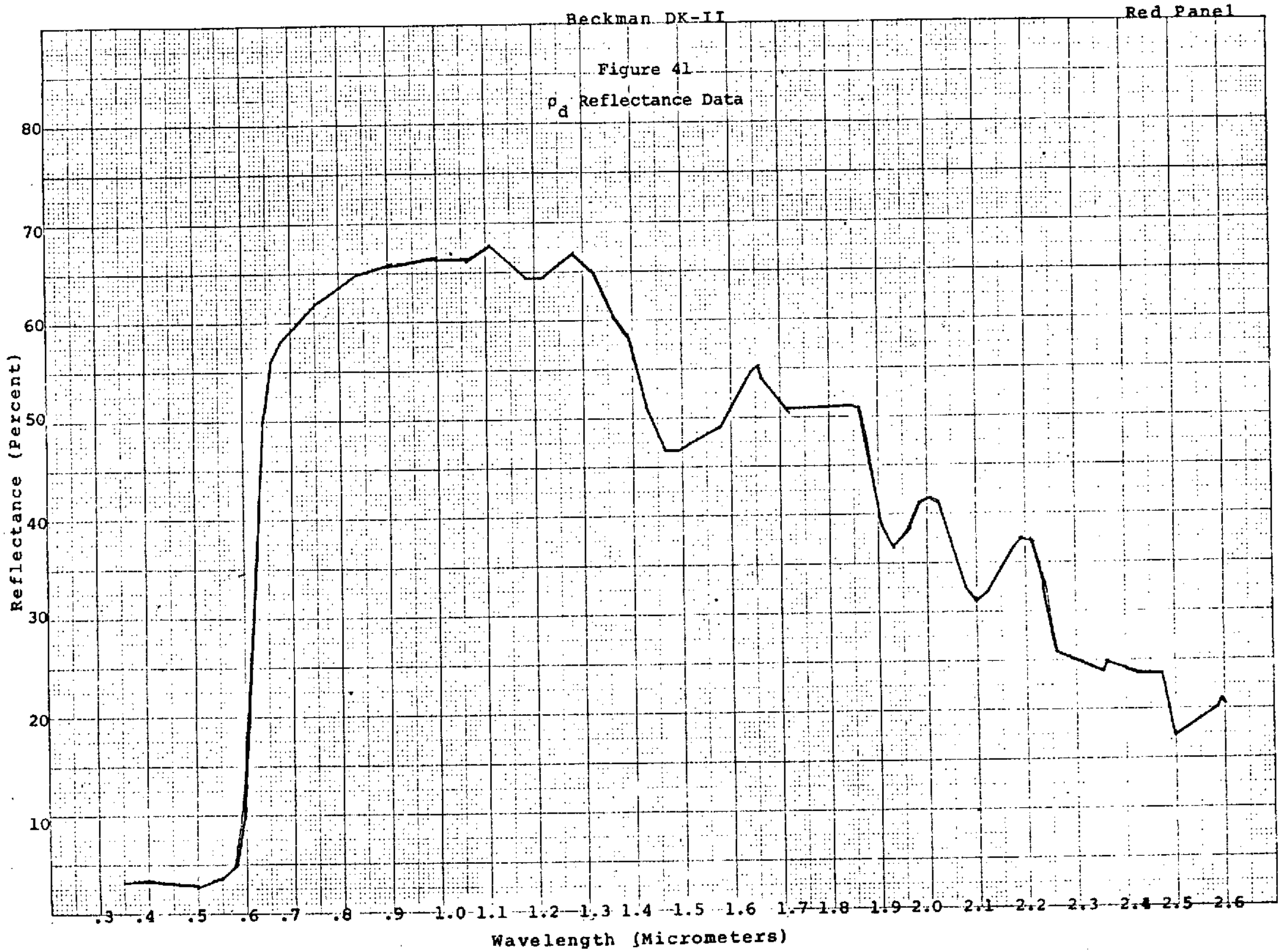
Sample 2117 AREA 101
Beckman DK-II
Gray Panel #3
Figure 38
ρ_d Reflectance Data
Reflectance (Percent)
80
70
60
50
40
30
20
10
.3
.4
.5
.6
.7
.8
.9
1.0
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2.0
2.1
2.2
2.3
2.4
2.5
2.6
Wavelength (Micrometers)



Beckman DK-II
Gray Panel #4
Figure 39
ρ_d Reflectance Data
80
70
60
50
40
30
20
10
Reflectance (Percent)
.3 .4 .5 .6 .7 .8 .9 1.0 1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8 1.9 2.0 2.1 2.2 2.3 2.4 2.5 2.6
Wavelength (Micrometers)



Sample 2119 AREA 101
Beckman DK-II
Gray Panel #5
Figure 40
ρd Reflectance Data
Reflectance (Percent)
80
70
60
50
40
30
20
10
.3 .4 .5 .6 .7 .8 .9 1.0 1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8 1.9 2.0 2.1 2.2 2.3 2.4 2.5 2.6
Wavelength (Micrometers)



Beckman DK-II
Red Panel
Figure 41
ρ_d Reflectance Data
Reflectance (Percent)
80
70
60
50
40
30
20
10
.3 .4 .5 .6 .7 .8 .9 1.0 1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8 1.9 2.0 2.1 2.2 2.3 2.4 2.5 2.6
Wavelength (Micrometers)

Beckman DK-II

Green Panel

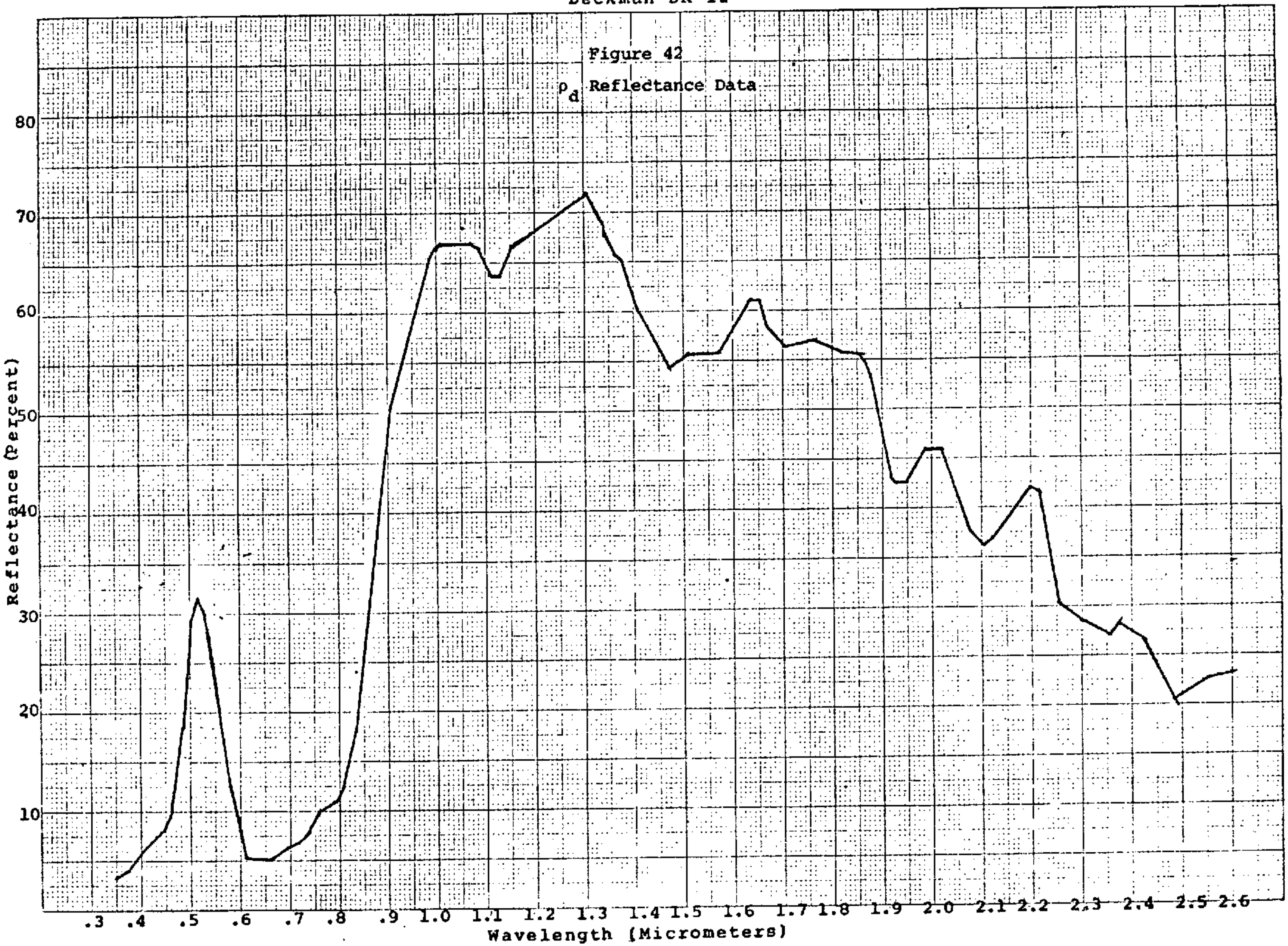
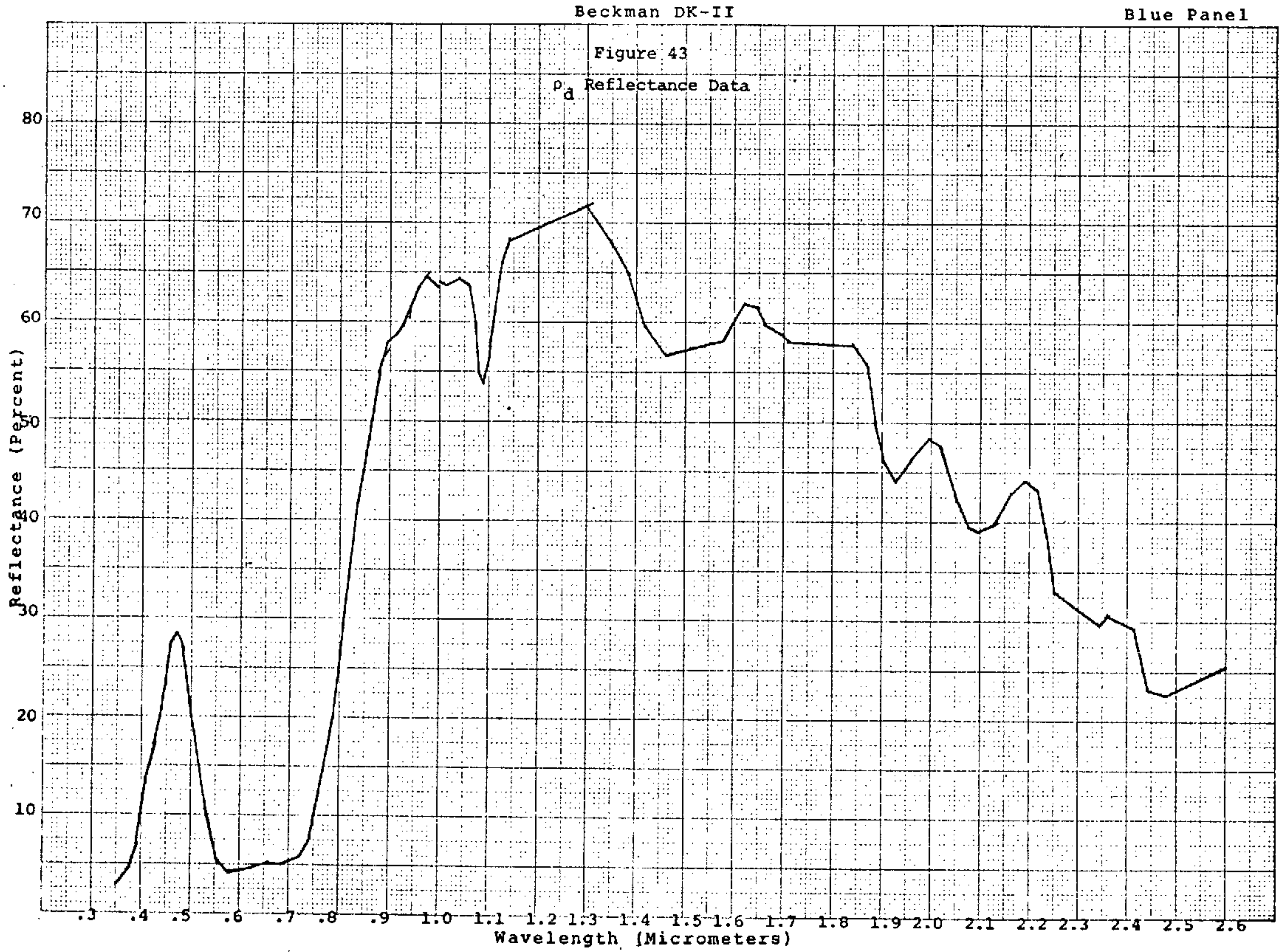


Figure 42

ρ_d Reflectance Data


Beckman DK-II
Blue Panel
Figure 43
ρ_d Reflectance Data
80
70
60
50
40
30
20
10
Reflectance (Percent)
.3 .4 .5 .6 .7 .8 .9 1.0 1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8 1.9 2.0 2.1 2.2 2.3 2.4 2.5 2.6
Wavelength (Micrometers)

APPENDIX 1. RADIANT POWER MEASURING INSTRUMENT

The Bendix RPMI (Radiant Power Measuring Instrument) is capable of making both radiance and irradiance measurements in four spectral regions in the visible and near infrared. The four spectral regions correspond to the ERTS MSS (Earth Resources Technology Satellite - MultiSpectral Scanner) bands 4, 5, 6, and 7. Figure 1 shows the relative spectral response of the RPMI for each of the four bands. (These data are from a Bendix bi-monthly progress report*.) Calibration measurements made at ERIM on one RPMI unit (S/N 100) are reported in this Appendix.**

The Bendix RPMI uses a transmissive diffuser to obtain a Lambertian, hemispherical, field of view. Since information was lacking on the angular response characteristics of the diffuser on the RPMI, measurements were made at ERIM to determine those characteristics. The data presented are normalized to the signal level at a zenith angle of 0° and also were corrected for the expected cosine response so that an ideal cosine receiver response would appear as a straight line with a magnitude of 1.0. The information is presented in a manner that indicates directly the difference between the ideal and real cosine receiver. The diffusivity measurements were made with the spectral band as a parameter. The data obtained are presented in Figures 2 through 5.

To make radiance measurements with the RPMI, a tube is installed over the cosine receiver, thus restricting its field of view. While data were available giving the effective solid angle of the instrument in this configuration, there were no data on the angular response. Therefore, measurements were made at ERIM to determine the angular response using the four wavelength bands as parameters. These measurements were made using a source which has an extent of 1/2° (Note: the extent of the sun also is 1/2°). The data are presented in Figures 6 through 9. The angular responses presented are absolutely correct only when a source has an extent of 1/2° because of the source used. The measurements are the result of the convolution of the

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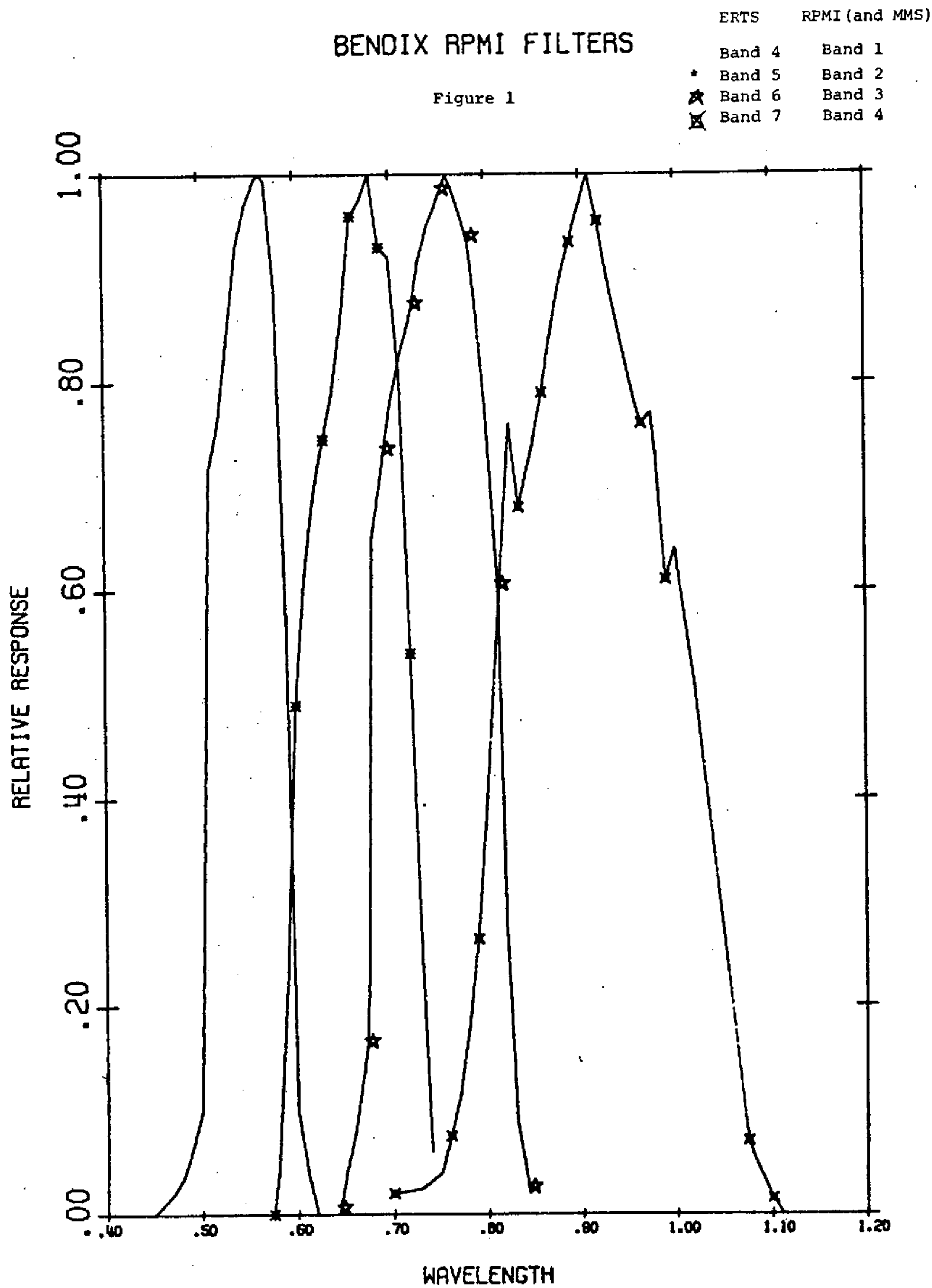
*Report Period 1 April to 1 June 1973, Contract NAS5-21863, Experiment PR303.

**The work described in this Appendix was performed under Contract Number NAS5-21783, Task VII (MMC 136) for NASA's Goddard Space Flight Center, Greenbelt, Maryland.

BENDIX RPMI FILTERS

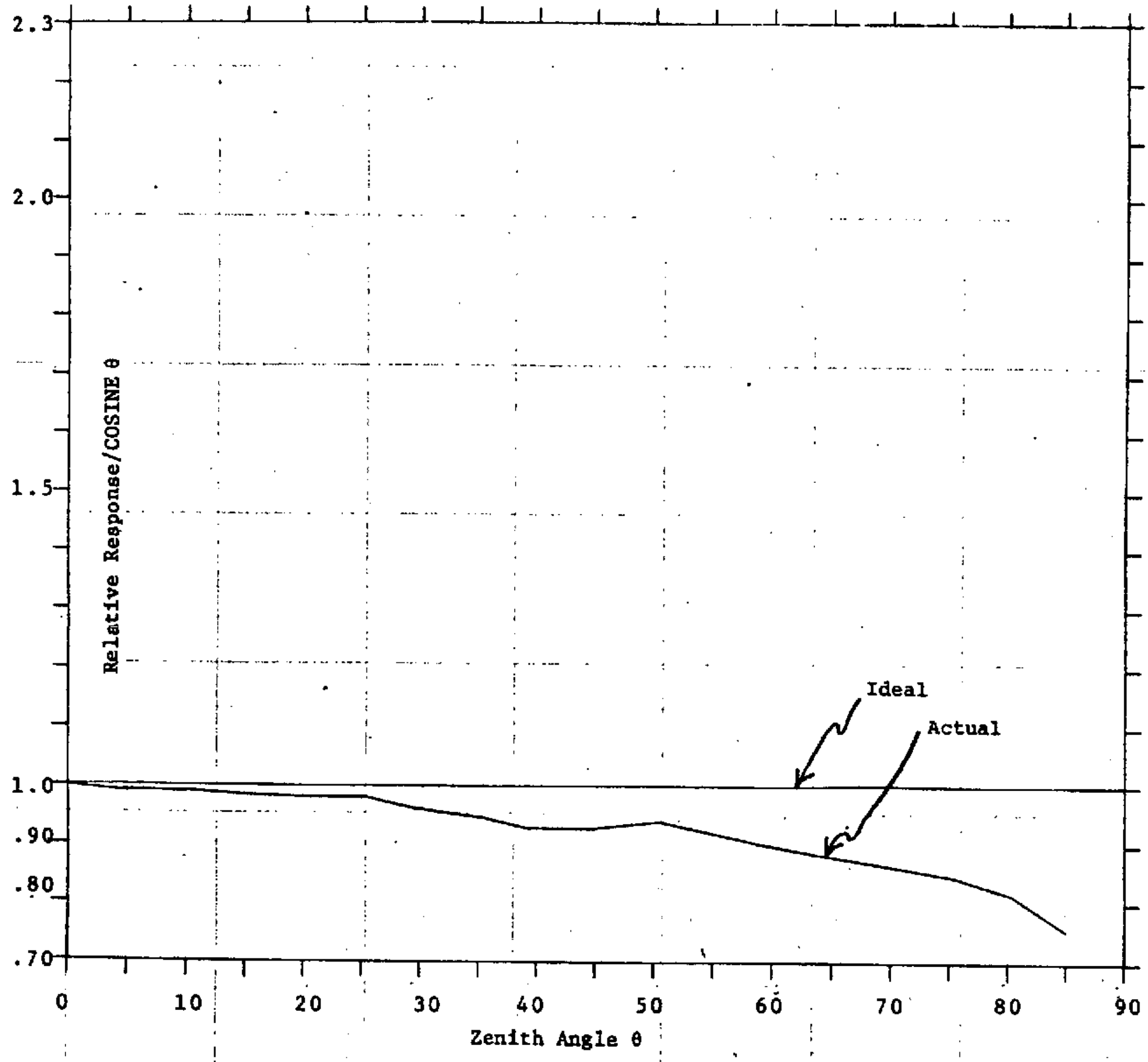
Figure 1



RELATIVE RESPONSE OF THE BENDIX RPMI's COSINE RECEIVER

ERTS Band 4, or RPMI Band 1

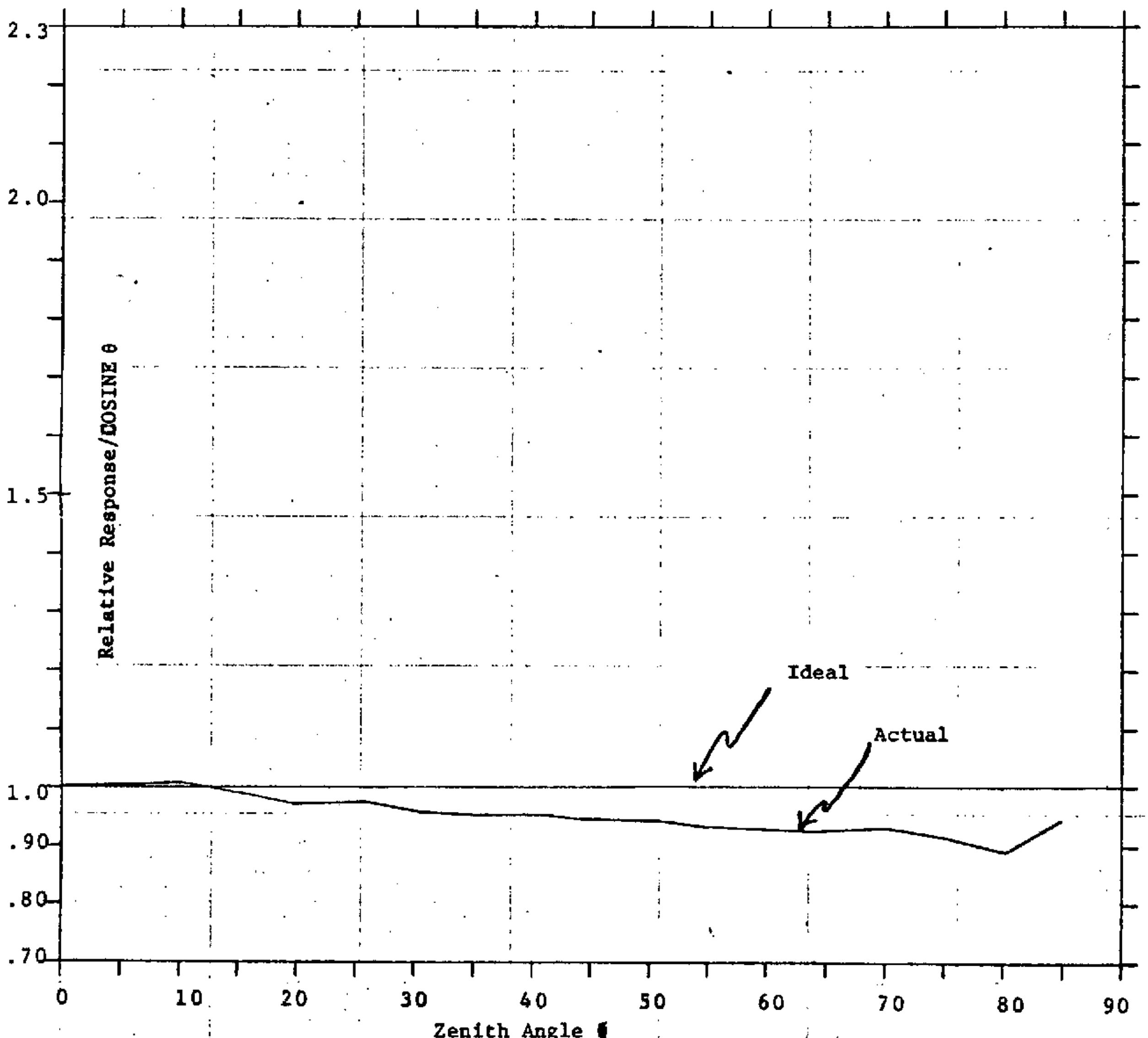
Figure 2



RELATIVE RESPONSE OF THE BENDIX RPMI's COSINE RECEIVER

ERTS Band 5, or RPMI Band 2

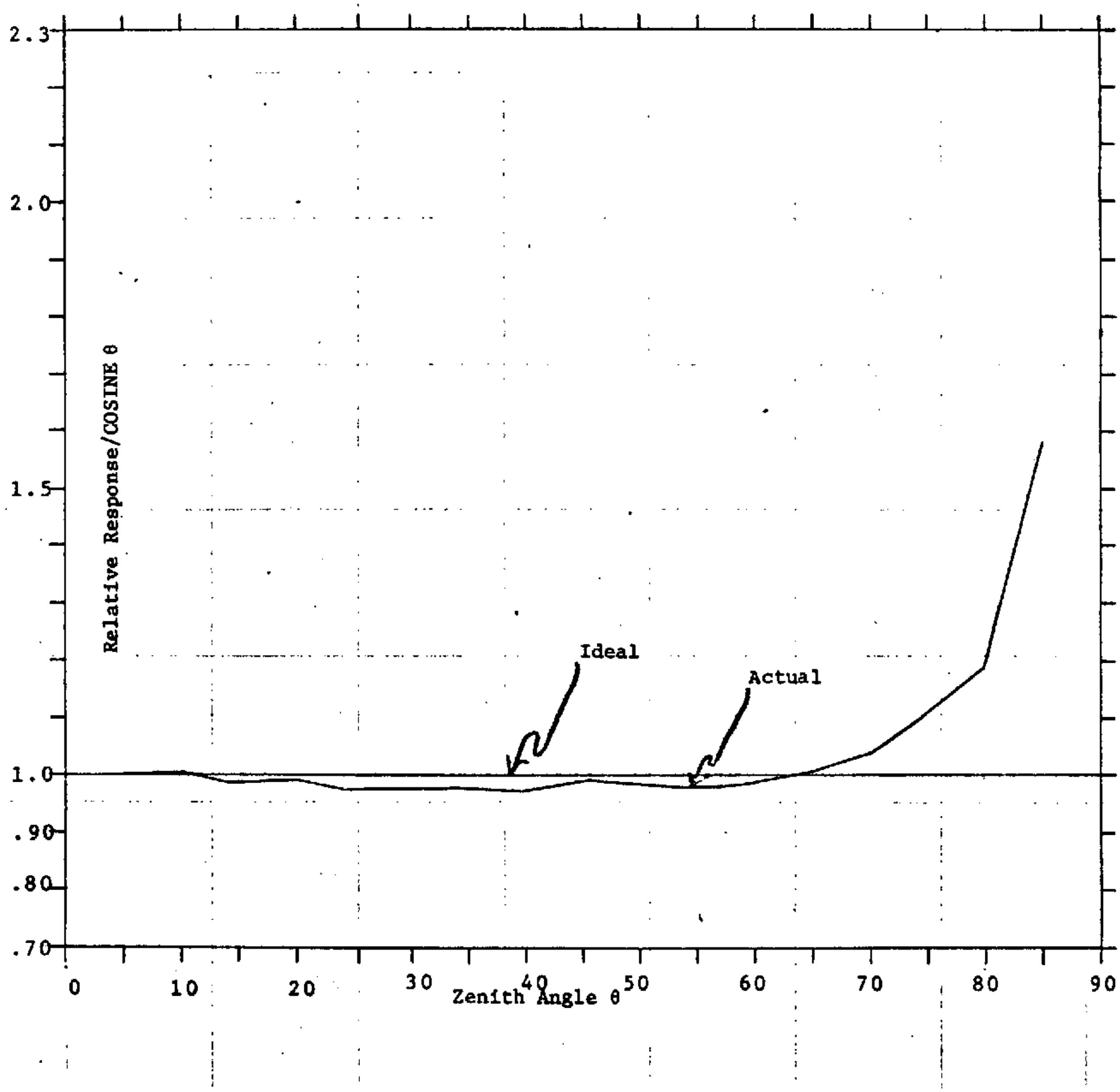
Figure 3



RELATIVE RESPONSE OF THE BENDIX RPMI's COSINE RECEIVER

ERTS Band 6, or RPMI Band 3

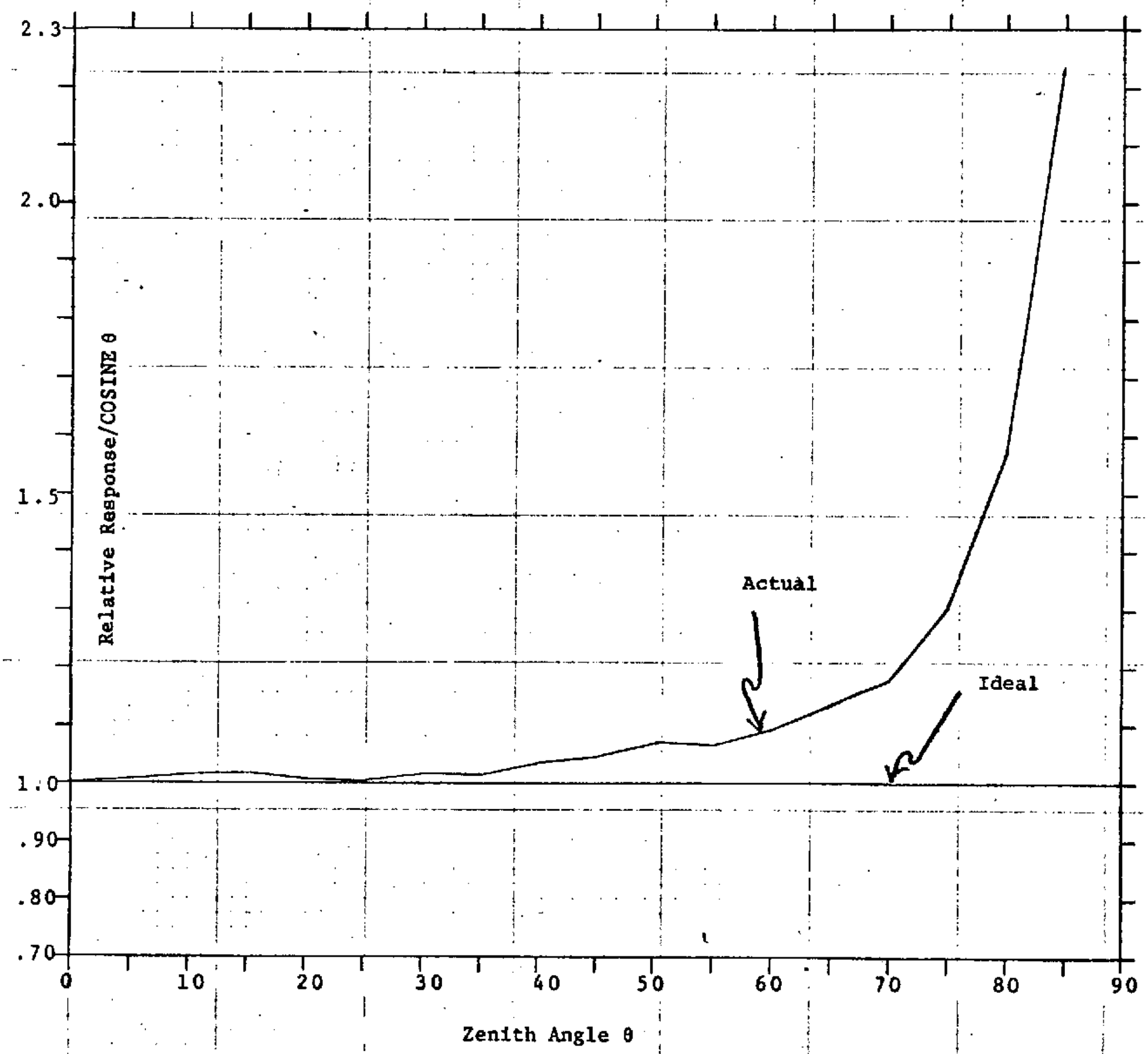
Figure 4



RELATIVE RESPONSE OF THE BENDIX RPMI's COSINE RECEIVER

ERTS Band 7, or RPMI Band 4

Figure 5



1/2° source with the actual angular response of the instrument. An example of the smoothing produced by an extended source is illustrated in Figure 10. The example shows how a particular angular response is affected by being smoothed with a source having an extent of 1°.

Independent radiance and irradiance calibrations were also made by ERIM personnel. The objective of radiometer calibration is to establish an accurate relationship between the output signal, S, and the irradiance or radiance within the spectral band of operation of the radiometer. That is,

$$S = R_E E(\lambda_1 \text{ to } \lambda_2)$$

for irradiance (E) and

$$S = R_L L(\lambda_1 \text{ to } \lambda_2)$$

for radiance (L) where the proportionality constants R_E and R_L are to be determined and λ_1 and λ_2 are the band limits.

The band of operation is found for each radiometer channel by normalizing the respective relative spectral responsivities $r(\lambda)$ to the peak. Thus,

$$\Delta\lambda = \int_0^\infty r(\lambda)d\lambda$$

determines the bandwidth, $\Delta\lambda$, and

$$\bar{\lambda}\Delta\lambda = \int_0^\infty \lambda r(\lambda)d\lambda$$

determines the band center, $\bar{\lambda}$. Therefore, the band limits, λ_1 and λ_2, are

$$\lambda_1 = \bar{\lambda} - \Delta\lambda/2$$

$$\lambda_2 = \bar{\lambda} + \Delta\lambda/2$$

The values of R_E and R_L can be determined by exposing the radiometer to a source providing a known spectral irradiance or radiance and observing the resulting signal.

Thus,

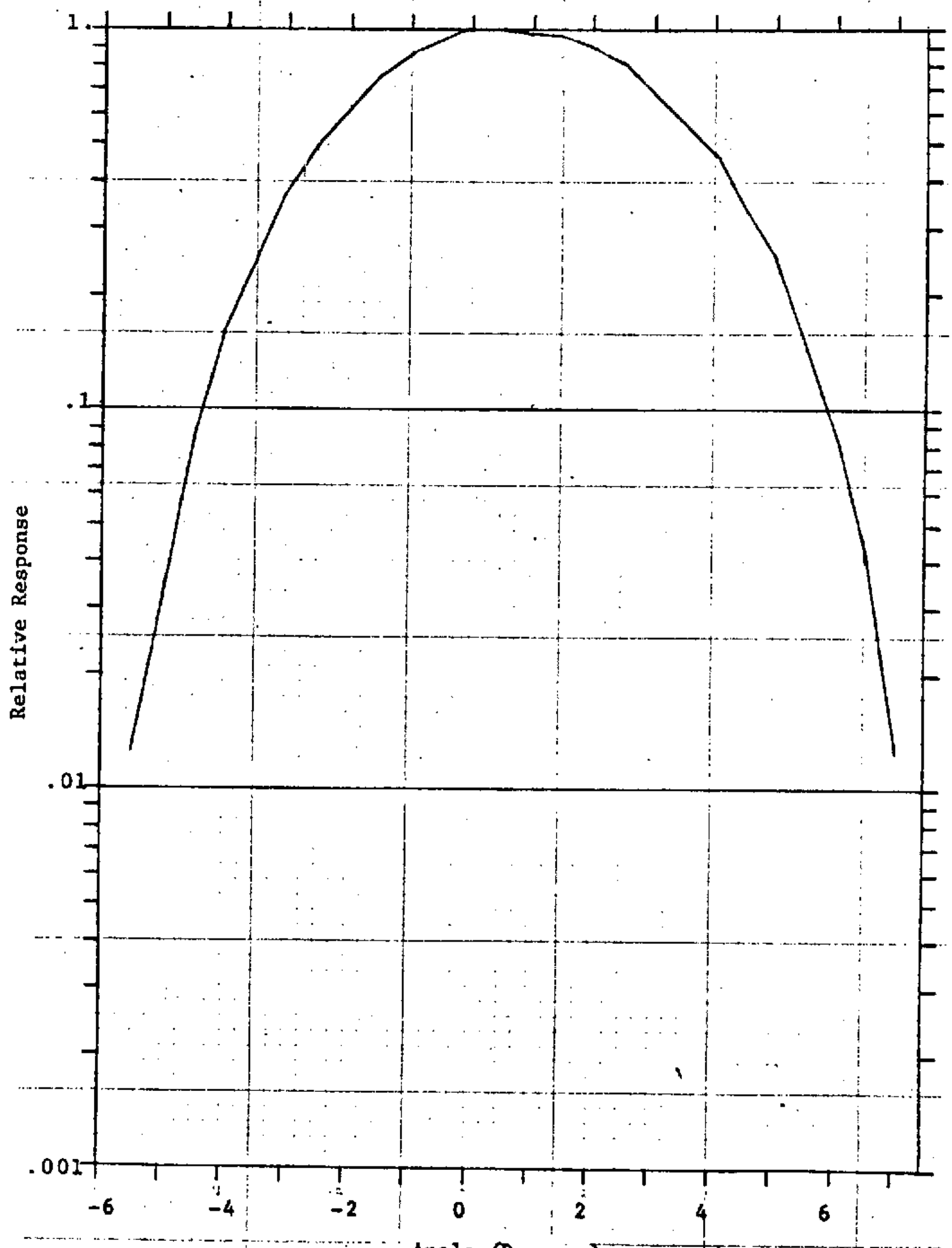
$$(1) \quad R_E = S(\text{observed})/E(\lambda_1 \text{ to } \lambda_2)$$

$$(2) \quad R_L = S(\text{observed})/L(\lambda_1 \text{ to } \lambda_2)$$

RELATIVE RESPONSE OF BENDIX RPMI

ERTS Band 4, RPMI Band 1

Figure 6

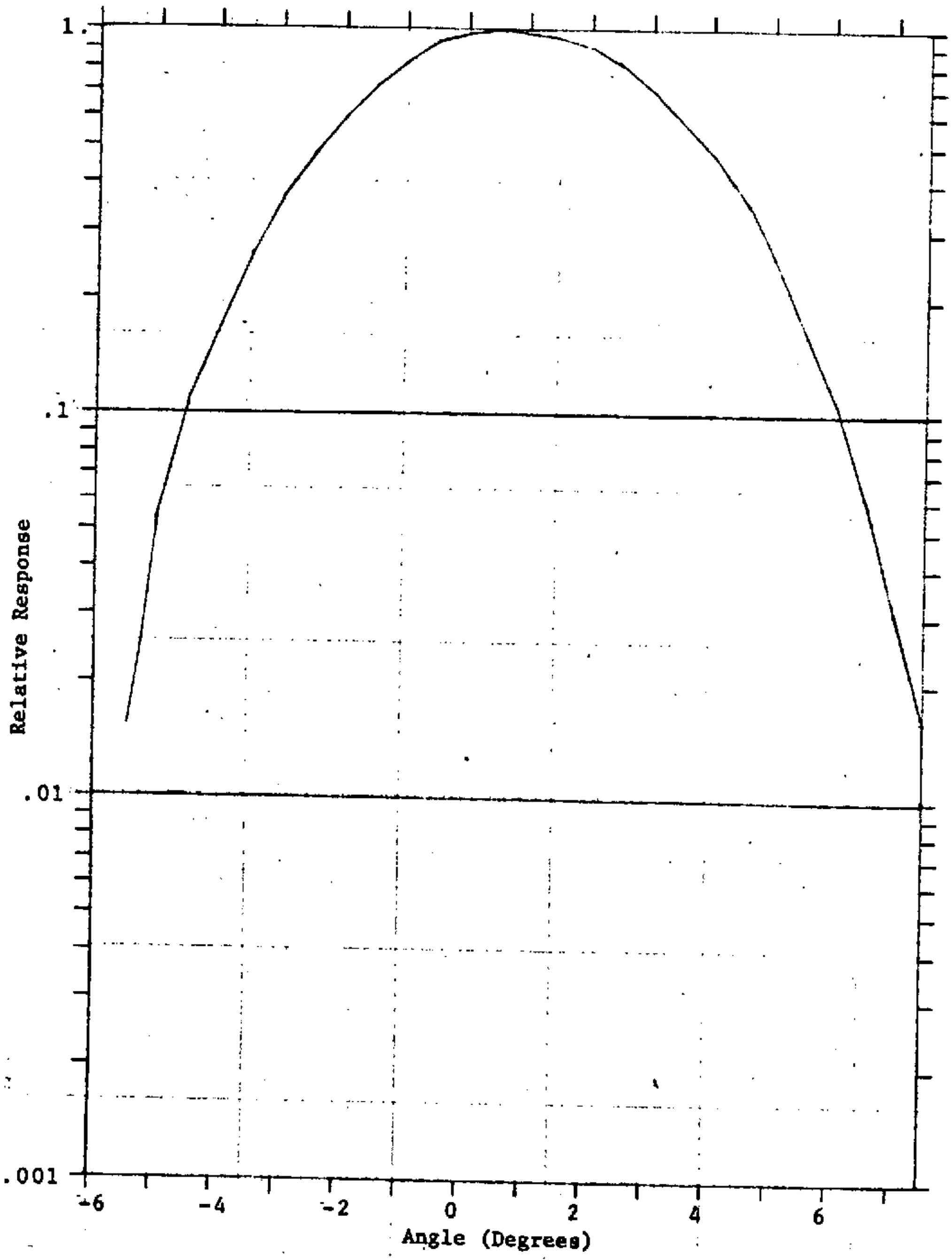


C-9

RELATIVE RESPONSE OF BENDIX RPMI

ERTS Band 5, RPMI Band 2

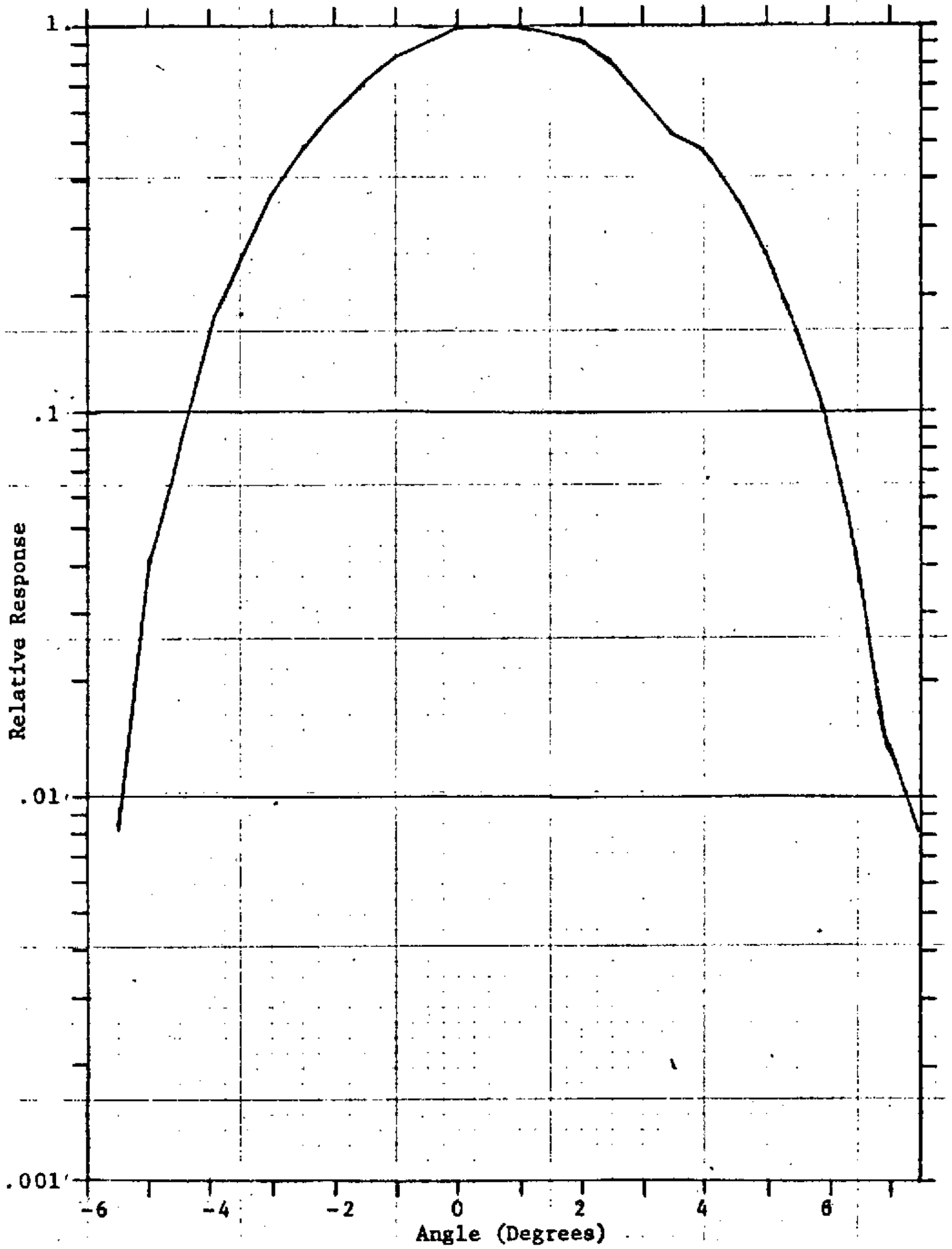
Figure 7



RELATIVE RESPONSE OF BENDIX RPMI

ERTS Band 6, RPMI band 3

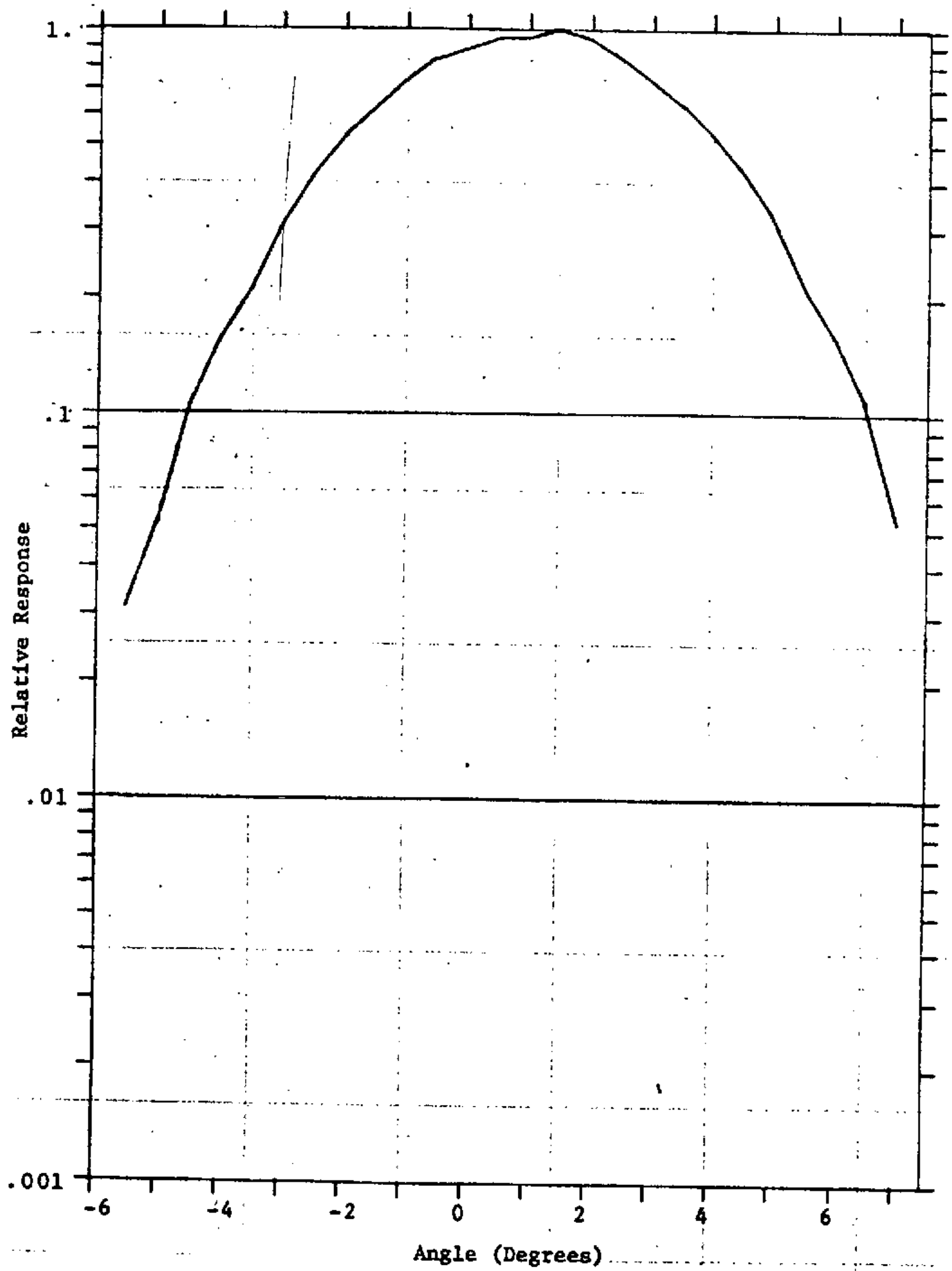
Figure 8

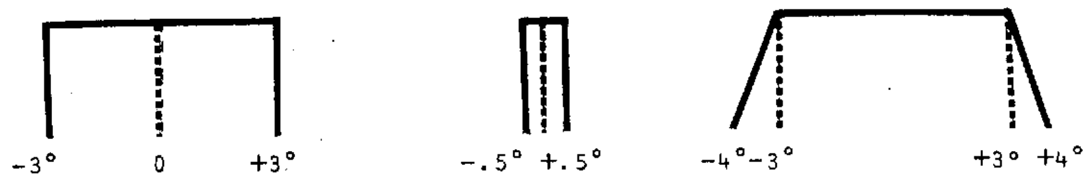


RELATIVE RESPONSE OF BENDIX RPMI

ERTS Band 7, RPMI Band 4

Figure 9





Angular Response of Ideal Instrument for a Point Source.

Angular Extent of a Source.

Angular Response of Instrument Using Extended Source.

Figure 10

ANGULAR RESPONSE OF IDEAL INSTRUMENT
FOR AN EXTENDED SOURCE

where $E(\lambda_1 \text{ to } \lambda_2)$ and $L(\lambda_1 \text{ to } \lambda_2)$ are found by numerical integration of the known spectral irradiance or radiance between the band limits λ_1 and λ_2.

If one assumes that the radiometer responds linearly with incident flux, then the exact relationship between output signal and the irradiance or radiance in the band of operation has been found for all sources which have the same spectral distribution as the calibration source.

The proportionality constants in Equations 1 and 2 are correct only for a target that has the same relative spectral irradiance or radiance as the calibration source. The source used for the calibration was a tungsten lamp, and since the instrument is used outdoors, it is desired to find the relationship for sunlight, the spectral distribution of which is markedly different from that of a tungsten source. Also, the spectrum of sunlight at ground level is different from that outside the atmosphere, and can vary throughout a day and from day to day.

The signal, S(sun), could be calculated (instead of observed) by the relation

$$S(\text{sun}) = R_E(\text{peak}) \int_o^\infty r(\lambda) E_\lambda(\text{sun}) d\lambda$$

and, hence, the required constant, R_E(sun) could be determined by

$$R_E(\text{sun}) = R_E(\text{peak}) \int_o^\infty r(\lambda) E_\lambda(\text{sun}) d\lambda / E(\lambda_1 \text{ to } \lambda_2, \text{ sun})$$

if the value of R_E(peak) were known. Values for E_λ(sun) are tabulated in references or can be calculated. (Note: The relative spectral irradiance of the source may be used because the ratio

$$\int_o^\infty r(\lambda) E_\lambda(\lambda) d\lambda / E(\lambda_1 \text{ to } \lambda_2)$$

is independent of the absolute magnitude of $E_\lambda(\lambda)$.) The results of a calibration experiment with a tungsten standard lamp allow the value of R_E(peak) to be computed since

$$S = R_E(\text{tung}) E(\lambda_1 \text{ to } \lambda_2, \text{ tung}) = R(\text{peak}) \int_o^\infty r(\lambda) E_\lambda(\text{tung}) d\lambda.$$

Consequently,

$$R(\text{peak}) = \frac{R_E(\text{tung})E(\lambda_1 \text{ to } \lambda_2,\text{tung})}{\int_0^\infty r(\lambda)\ E_\lambda(\text{tung})d\lambda}$$

Therefore, by substitution

$$R_E(\text{sun}) = \frac{\int_0^\infty r(\lambda)E_\lambda(\text{sun})d\lambda/E(\lambda_1 \text{ to } \lambda_2,\text{ sun})}{\int_0^\infty r(\lambda)E_\lambda(\text{tung})d\lambda/E(\lambda_1 \text{ to } \lambda_2,\text{ tung})} R_E(\text{tung})$$

The relation

$$S = R_E(\text{sun})E(\lambda_1 \text{ to } \lambda_2,\text{ sun}),$$

is the desired exact relationship between output signal and irradiance in the band of operation for all sources which have the same spectral distribution as sunlight.

A suitable constant of proportionality may be derived for any other kind of spectral distribution in the same way as for sunlight.

In general, if one defines a source constant, $K_E(i)$, for the ith source as

$$K_E(i) = \int_0^\infty r(\lambda)E_\lambda(i,\lambda)d\lambda/E(\lambda_1 \text{ to } \lambda_2,i).$$

then the relation between the values $R_E(i)$ and the R_E(calibration) is

$$R_E(i) = \frac{K_E(i)}{K_E(\text{calibration})} R_E(\text{calibration})$$

and the exact relationship between output signal and irradiance in the band of operation is

$$S = R_E(i)E(\lambda_1 \text{ to } \lambda_2,i).$$

When the spectral distribution is not known, the best overall compromise value for R_E is R_E(peak), to yield the best overall accuracy.

The irradiance calibration was performed using a standard of spectral irradiance. The radiance calibration was accomplished using a reflecting panel of 3M White Paint illuminated by a standard of spectral irradiance whic is traceable to NBS. The calibration constants were evaluated using Equatio

1, for the irradiance constants, and Equation 2, for the radiance constants. Table I contains the calculated values of the reciprocals of the proportionality constants R_E(peak), R_L(peak), R_E, and R_L for each of the RPMI bands. The reciprocals are given because calibration constants are conventionally given as multiplicative constants (i.e. in data reduction the expression to be evaluated is $E(\lambda_1 \text{ to } \lambda_2) = S\, R_E^{-1}$ where S is the meter reading, and R_E is the calibration constant).

The calibration constants presented in Table I cannot be compared directly with the calibration constants reported by Bendix because Bendix used a different calibration procedure and reported the reduced data in a different set of units. The differences between the calibration procedures and units have not yet been reconciled.

Table II gives the values of $\Delta\lambda$ and $\bar{\lambda}$ as well as the constant K(calibration) for the calibration sources.

TABLE I

RPMI Band	ERTS Band	$(R_E\text{peak})^{-1}$ $\left(\frac{\text{mW-cm}^{-2}}{\text{unit}}\right)$	$(R_L\text{peak})^{-1}$ $\left(\frac{\text{mW-cm}^{-2}\text{-ster}^{-1}}{\text{unit}}\right)$	$(R_E)^{-1}$ $\left(\frac{\text{mW-cm}^{-2}}{\text{unit}}\right)$	$(R_L)^{-1}$ $\left(\frac{\text{mW-cm}^{-2}\text{-ster}^{-1}}{\text{unit}}\right)$
1	4	.894	64.1	.847	60.7
2	5	1.130	80.1	1.198	84.9
3	6	1.35	93.4	1.471	101.8
4	7	1.928	133.5	1.799	124.6

$$E_i = S_i R_{Ei}^{-1} \quad \text{and} \quad L_i = S_i R_{Li}^{-1}$$

E_i = Irradiance in Band i

L_i = Radiance in Band i

S_i = Meter reading for Band i

$R_{E_i}^{-1}$ and $R_{L_i}^{-1}$ = Irradiance and radiance calibration constants for Band i.

TABLE II

RPMI Band	$\Delta\lambda$ [μm]	$\overline{\lambda}$ [μm]	Irradiance Standard: $E(\lambda_1 \text{ to } \lambda_2)$ mW-cm^{-2}	Irradiance Standard: $\int_0^\infty r(\lambda)E(\lambda)d\lambda$ mW-cm^{-2}	Radiance Standard: $L(\lambda_1 \text{ to } \lambda_2)$ mW-cm^{-2}-ster^{-1}	Radiance Standard: $\int_0^\infty r(\lambda)L(\lambda)d\lambda$ mW-cm^{-2}-ster^{-1}	$K_E = \frac{\int_0^\infty r(\lambda)E(\lambda)d\lambda}{E(\lambda_1 \text{ to } \lambda_2)}$	$K_L = \frac{\int_0^\infty r(\lambda)L(\lambda)d\lambda}{L(\lambda_1 \text{ to } \lambda_2)}$
1	.080	.550	.206	.195	.0566	.0536	.947	.947
2	.109	.664	.426	.452	.117	.124	1.06	1.06
3	.124	.748	.612	.668	.168	.184	1.09	1.09
4	.196	.925	1.20	1.12	.329	.307	.933	.933